Synthetic Method

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Catalytic [3+2] Annulation of Aminocyclopropanes for the Enantiospecific Synthesis of Cyclopentylamines. **

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Cyclic structures are encountered in the core of most bioactive synthetic and natural products. Carbo- and heterocyclic rings give rigidity to molecules, allowing the fixation of functional groups in the space. As a result, specific interactions with biomolecules without important entropy costs become possible. Nitrogen-based functional groups are especially important in synthetic and medicinal chemistry. In this respect, cyclopentylamines constitute an important subclass of cyclic structures, present in both relatively simple natural products, such as the antibiotic and antiviral aristeromycin (**1**),[1] or in dauntingly complex polycyclic structures, such as palau'amine (**2**), one of the most sought for targets in modern organic chemistry (Figure 1).[2] They are also part of purely synthetic drugs. For example, ramipril (**3**), an angiotensin-converting enzyme (ACE) inhibitor, was one of the top 100 generic drugs in 2008 for the treatment of high blood pressure and heart failure.[3] Consequently, the development of new synthetic procedures to access polysubstituted cyclopentyl amines is an important task for organic chemists.[4]

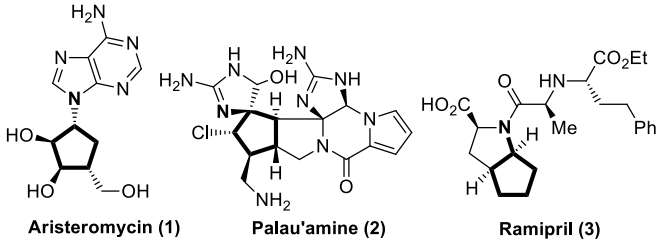
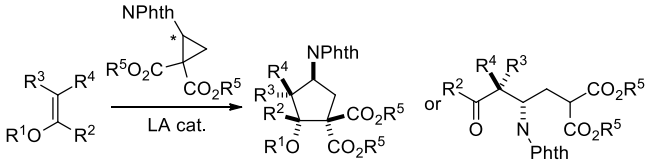


Figure 1. Cyclopentyl Amines in Natural and Synthetic Products.

One of the most efficient ways to access 5-membered rings is by concerted cycloaddition reactions or related stepwise annulation processes. In particular, the formal [3+2] cycloaddition, more correctly called [3+2] annulation, of donor-acceptor activated cyclopropanes[5] with alkenes or alkynes,[6] carbonyls[7] and imines[8] has been highly successful in the last decades for the synthesis of cyclopentanes/enes, tetrahydrofurans and pyrrolidines respectively. Cyclopropanes bearing electron-donating oxygen or aromatic substituents have been especially useful in Lewis or Brønsted acid-catalyzed reactions. In contrast, annulation reactions of aminocyclopropanes have been limited to radical-initiated ring opening involving electron-rich amines.[9] To the best of our knowledge, no catalytic [3+2] annulation of aminocyclopropanes has ever been reported. Donor-acceptor aminocyclopropanes have been mostly used as 1,4-imino carbonyl precursors,[10] as well as in a few rare ring-opening reactions.[11] In 2010, we applied them in an efficient formal homo-Nazarov cyclization for the synthesis of natural alkaloids.[12] However, a formal cycloaddition approach would be inherently more convergent and efficient to access molecular complexity. Herein, we would like to report phthalimide-substituted acceptor cyclopropanes as unique partners in [3+2] annulation reactions with silyl and alkyl enol ethers (Scheme 1). High yields and diastereo-selectivities were obtained using $SnCl_4$ as catalyst with a broad range of enol ethers as substrates. The reaction was stereospecific in relation to the configuration of the enol ether and enantiospecific, giving an asymmetric access to chiral cyclopentylamines. Finally, the use of $In(OTf)_3$ as catalyst gave access to important acyclic β-amino ketones and deprotection of the phthalimide group, as well as further functionalization, was possible under mild conditions.



Scheme 1. Lewis Acid (LA)-catalyzed reactions of aminocyclopropanes with enol ethers. PhthN = Phthalimide

As a model system to study the annulation reaction with several aminocyclopropanes **4a-f**, stable enol silyl **5a** was chosen as an electron-rich alkene, as it was expected to have a higher reactivity than non-activated alkenes and should also allow a good control over the regioselectivity (Table 1). We started with $SnCl_4$ as Lewis acid in dichloromethane, as these conditions had been successful in the case of oxygen-substituted cyclopropanes.[6f] However, no reaction was observed with cyclopropanes **4a**, **4b** and **4c** bearing a Cbz protected amine, a lactam or an oxazolidinone substituent respectively (entries 1-3). At this point, we attempted to enhance the reactivity of lactam- and oxazolidinone-substituted cyclopropanes by the introduction of a second ester group.[6d,6h,7c-e] However, the obtained cyclopropanes were unstable and already decomposed during purification. These results further emphasized how difficult it is to modulate the reactivity of aminocyclopropanes when compared with other donor-acceptor cyclopropanes. In order to decrease the electron-donor ability of the nitrogen group, phthalimidecyclopropane **4d** was investigated next (entry 4). For the first time, a clean annulation was observed, giving exclusively the *trans* diastereoisomer **6da** of the desired cyclopentylamine![13] Importantly, phthalimide-substituted cyclopropanes can be obtained

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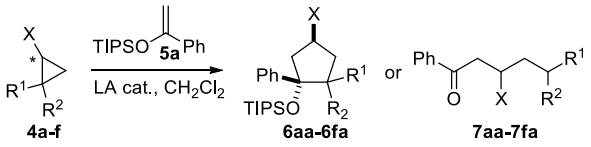
in a single step on a multi-gram scale from commercially available *N*-vinylphthalimide and diazomalonates by Rh-catalyzed cyclopropanation.[14] On the other hand, removal of one of the ester groups led again to an unreactive cyclopropane (**4e**, entry 5). The use of $SnCl_4$ at room temperature led to partial ring opening (entry 6). At this point, several other Lewis acids successful in related [3+2] annulations[6-8] were examined (entries 7-12). Immediately, the exceptional reactivity of cyclopropane **4d** became apparent, as full conversion could be obtained with a broad range of Lewis acids.[15] Nevertheless, a mixture of cyclization and homo-aldol products was obtained in most cases, with the exception of $In(OTf)_3$ (entry 11) and $HNTf_2$ (entry 12), which led to complete ring opening. Finally, full conversion to a single diastereoisomer was also obtained with dimethyl ester **4f** (entry 13) and the cyclopentylamine could be obtained in 95% isolated yield after column chromatography in this case.

Table 1. Optimization of the [3+2] Annulation.

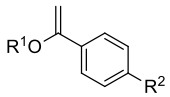
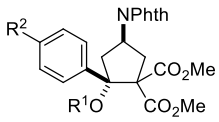
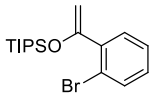
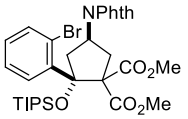
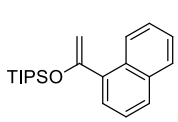
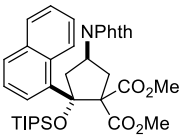
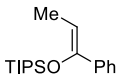
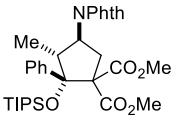
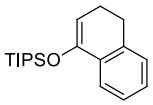
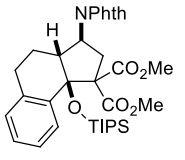
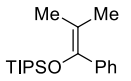
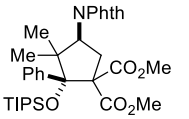
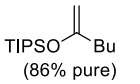
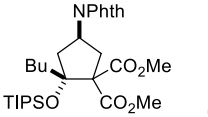
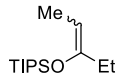
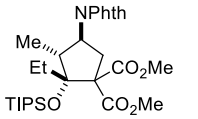
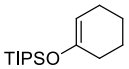
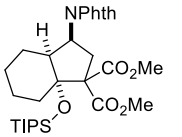
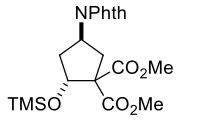
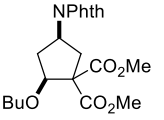
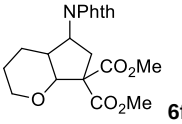


entry	R^1/R^2	X	Catalyst, Conditions[a]	Conversion[b]	ratio **6**:**7**[c]
1	CO_2Et/H	 (**4a**)	$SnCl_4$, -78 °C	0%	-
2	CO_2Et/H	 (**4b**)	$SnCl_4$, -78 °C	0%	-
3	CO_2Et/H	 (**4c**)	$SnCl_4$, -78 °C	0%	-
4	CO_2Et/CO_2Et	NPhth, (**4d**)	$SnCl_4$, -78 °C	100% (98%)[d]	>20:1
5	CO_2Et/H	NPhth, (**4e**)	$SnCl_4$, -78 °C	0%	-
6	CO_2Et/CO_2Et	NPhth, (**4d**)	$SnCl_4$, rt	100%	1:1
7	CO_2Et/CO_2Et	NPhth, (**4d**)	$Cu(OTf)_2$, rt	100%	5:1
8	CO_2Et/CO_2Et	NPhth, (**4d**)	$Yb(OTf)_2$, rt	100%	5:1
9	CO_2Et/CO_2Et	NPhth, (**4d**)	$Sn(OTf)_2$, rt	100%	2:1
10	CO_2Et/CO_2Et	NPhth, (**4d**)	$Sc(OTf)_3$, rt	100%	1:3
11	CO_2Et/CO_2Et	NPhth, (**4d**)	$In(OTf)_3$, rt	100%	<1:20
12	CO_2Et/CO_2Et	NPhth, (**4d**)	$HNTf_2$, rt	100%	<1:20
13	CO_2Me/CO_2Me	NPhth, (**4f**)	$SnCl_4$, -78 °C	100% (95%)[d]	>20:1

[a] Reaction conditions: 0.040 mmol **4**, 0.060 mmol **5a**, 0.008 mmol catalyst, 0.5 mL CH_2Cl_2, 1 h. [b] Conversion of **4** determined by ^{1}H-NMR. [c] Determined by ^{1}H-NMR in the crude mixture. [d] Isolated yield after column chromatography on 0.30 mmol scale.

When considering the importance of cyclopentylamines, and the lack of general methods for their synthesis, we decided to investigate first the scope of the cycloaddition reaction using $SnCl_4$ as catalyst with cyclopropane **4f** (Table 2).[16] The size of the silyl group on the enol ether had no influence on yield or selectivity and the desired product was obtained in quantitative yield with very high diastereoselectivity (entries 1-3).[17] Both electron-donating and electron-withdrawing groups in *para* or *ortho* position were well tolerated on enol ethers derived from acetophenone (entries 4-9).

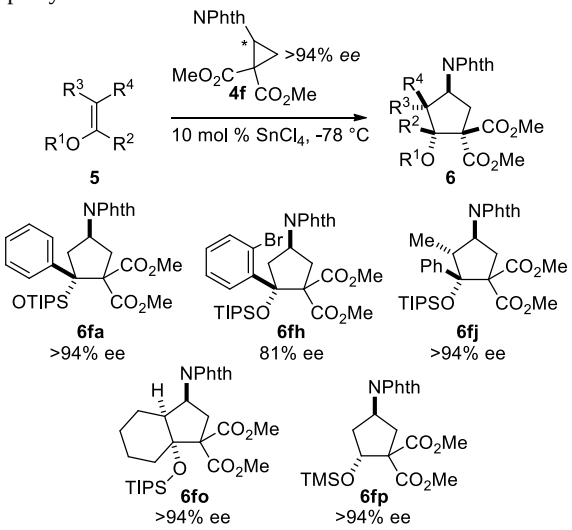
Table 2. Scope of the [3+2] Annulation.

entry	olefin		product		yield, dr[a]
					
1	R^1=TIPS, R^2=H:	**5a**	R^1=TIPS, R^2=H:	**6fa**	95%, >20:1
2	R^1=TBS, R^2=H:	**5b**	R^1=TBS, R^2=H:	**6fb**	98%, >20:1
3	R^1=TMS, R^2=H:	**5c**	R^1=TMS, R^2=H:	**6fc**	95%, >20:1
4	R^1=TIPS, R^2=F:	**5d**	R^1=TIPS, R^2=F:	**6fd**	91%, >20:1
5	R^1=TIPS, R^2=CO_2Me:	**5e**	R^1=TIPS, R^2=CO_2Me:	**6fe**	95%, >20:1
6	R^1=TIPS, R^2=CN:	**5f**	R^1=TIPS, R^2=CN:	**6ff**	70%, >20:1
7	R^1=TIPS, R^2=OMe:	**5g**	R^1=TIPS, R^2=OMe:	**6fg**	99%, >20:1
8		**5h**		**6fh**	92%, >20:1
9		**5i**		**6fi**	91%, >20:1
10		**5j**		**6fj**	92%, 20:1
11		**5k**		**6fk**	91%, 10:1
12		**5l**		**6fl**	81%, 4:1
13	 (86% pure)	**5m**		**6fm**	96%, 17:1 (60%)[b]
14	 *E*:*Z* = 1:8	**5n**		**6fn**	96%, 11:4:1
15		**5o**		**6fo**	90%, 4:1
16		**5p**		**6fp**	77%, 20:1
17		**5q**		**6fq**	99%, 20:1
18		**5r**		**6fr**	99%, 1.7:1

[a] Reaction conditions: 0.45 mmol **5**, 0.30 mmol **4f**, 0.015 mmol $SnCl_4$, in 2 mL CH_2Cl_2, 1 h, -78°C. [b] Yield of major product determined by ^{1}H NMR. Contaminated by other regioisomers.

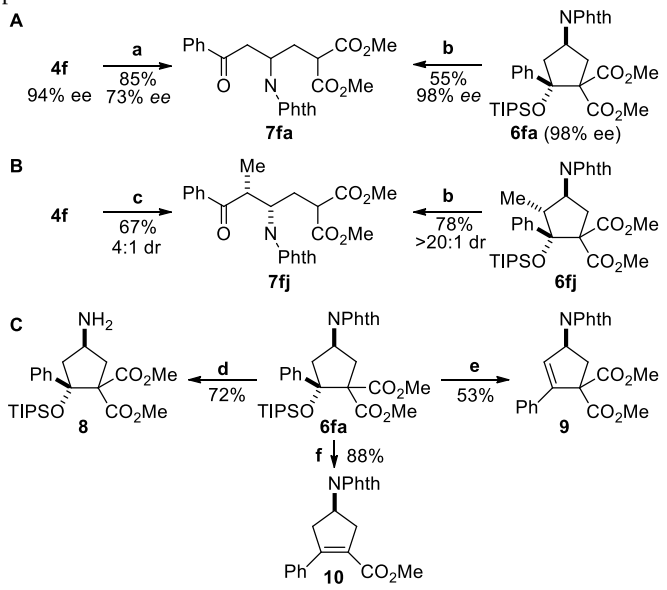
The yields were quantitative, except in the case of a cyanophenyl-substituted enol ether **5f**, which led to a slow reaction with incomplete conversion (entry 6). The reaction was stereospecific with *Z* enol ether **5j** giving a highly substituted cyclopentylamine **6fj** with perfect diastereoselectivity (entry 10). Interestingly, the opposite diastereoisomer with the nitrogen and the oxygen in a *syn* relationship was obtained using the enol ether **5k** derived from tetralone (entry 11). Trisubstituted enol ether **5l** could also be used, giving a sterically congested product with two all-carbon *N*-substituted quaternary centers and one tertiary silyloxy group next to each other (entry 12). We then turned to silyl enol ethers derived from aliphatic ketones (entries 13-15). Gratifyingly, these substrates also worked very well in the annulation reaction, but the difficulties in obtaining distereomerically pure regioisomers of the enol ethers led to product mixtures in case of acyclic substrates (entry 13-14). The diastereoselectivity was moderate only in the case of cyclic enol ether **5o** (entry 15). The commercially available silyl enol ether **5p** derived from acetaldehyde gave the secondary alcohol product also with high diastereoselectivity, demonstrating that the reaction was not limited to enol ethers derived from ketones (entry 16). Finally, alkyl enol ethers could also be used (entries 17-18). Good diastereoselectivity was obtained in the case of acyclic substrate **5q** (entry 17), but cyclic substrate **5r** gave no selectivity in the annulation reaction (entry 18). Taken together, these results emphasize the exceptional properties of cyclopropane **4f** in [3+2] annulation reactions with enol ethers. Most reported methods with other classes of donor-acceptor cyclopropanes for annulation with alkenes led to lower yields and diastereoselectivities or a limited scope.[6]

When considering previous works on annulation reactions of donor-acceptor cyclopropanes,[7c] two mechanisms could be envisaged for the first step of the annulation: either as stepwise process involving ring-opening of the cyclopropane to form a zwitterionic intermediate followed by attack of the enol ether, or a process via an "intimate ion pair "[7d] involving a concerted attack of the enol ether *anti* to the malonates.[18] When using an enantiopure aminocyclopropane, racemization would be expected in the former case, whereas the latter would lead to an enantiospecific reaction. In the event, when enantiopure aminocyclopropane **4f** was used,[19] an enantiospecific reaction was observed with all substrates except in the formation of **6fh** (Scheme 2), giving access to enantiopure cyclopentylamines.



Scheme 2. Enantiospecific reaction of cyclopropane **4f**.

To further establish the synthetic potential of the method, a few transformations of the cyclopentylamine products were examined (Scheme 3). Ring-opened product **7fa** can be obtained in one single step from aminocyclopropane **4f** using $In(OTf)_3$ as catalyst, but in this case, a partial racemization was observed (Scheme 3, **A**). In contrast, reaction of **6fa** in the presence of $In(OTf)_3$ led to a smooth transformation to the acyclic β-amino ketone **7fa** without loss of the enantiopurity. Also α-substituted β-amino ketone **7fj** can be obtained directly from **4f**, but with only 4:1 dr (Scheme 3, **B**). If cyclopentylamine **6fj** is formed prior to ring-opening, perfect *syn* diastereoselectivity is observed. As stereocontrol in the case of acyclic products is especially challenging, this is an important result. Finally, it is also possible to keep the cyclopentane ring in further transformations (Scheme 3, **C**). Deprotection of the phthalimide was possible under mild conditions.[20] Two isomeric cyclopentenylamines **9** and **10** could be obtained using either trimethylsilyl triflate or Krapcho decarboxylation conditions,[21] respectively. The obtained cyclopentenylamines are themselves parts of important bioactive compounds, such as the drug Abacavir, used in the treatment of HIV infection,[22] or can be used as platforms for further functionalization.



Scheme 3. Transformations of the cyclopentyl amines. Reaction conditions: a) **5a**, 20 mol % $In(OTf)_3$, CH_2Cl_2, RT; b) 20 mol % $In(OTf)_3$, CH_2Cl_2, RT; c) **5j**, 20 mol % $In(OTf)_3$, CH_2Cl_2, RT; d) 1,2-diamino-ethane, *i*PrOH, 80 °C; e) TMSOTf, CH_2Cl_2, 0 °C; f) NaCl, DMSO, H_2O, 170 °C.

In summary, we have reported the first catalytic [3+2] annulation of aminocyclopropanes with enol ethers. The introduction of a phthalimide group on a cyclopropane diester was key to enable high yield and selectivity in the reaction. Quantitative yields and a very broad scope made the reaction highly useful for the synthesis of substituted cyclopentylamines, for which truly general synthetic methods are scarce. As the reaction is enantiospecific, enantiopure cyclopentylamines can be easily obtained. Finally, substituted β-amino ketones or useful cyclopentenylamines can easily be obtained, either directly from the cyclopropane or from the cyclopentylamine products.

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Keywords: Aminocyclopropanes · CATALYSIS · Cycloaddition react. · Cyclopentylamines · Enantiospecific Reaction · Stereoselectivity.

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[13] The structure and relative configuration of **6da** was determined by X-ray analysis. See supporting information.

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[15] See supporting information for a full range of tested Lewis and Brønsted acids.

[16] The dimethylcyclopropanedicarboxylate was used preferentially as the products were easier to characterize by NMR methods.

[17] The structures and relative configurations of compounds **6da**, **6fk**, **6fp** and **6fr** was confirmed by X-ray analysis, and of compounds **6fj** by 2D-NMR analysis. The structures and relative configurations of the others were deduced by analogy. The phthalimide group was instrumental in giving high crystallinity to most products in this work. See supporting information.

[18] The determination of the absolute configuration of the aminocyclopropane and cyclopentylamine would allow us to confirm that the reaction in fact proceeded via inversion. These further studies on the reaction mechanism are currently ongoing in our group and the result will be reported in a future full account of our work.

[19] The enantiomers of cyclopropanes **4f** were conveniently separated by chiral column chromatography. Investigations towards a resolution or an asymmetric synthesis of **4f** are currently ongoing in our group.

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Synthetic Method

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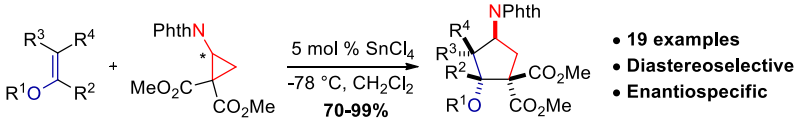
Catalytic [3+2] Annulation of Aminocyclopropanes for the Enantiospecific Synthesis of Cyclopentylamines.



Also with Nitrogen: The first catalytic [3+2] annulation of aminocyclopropanes with enol ethers is reported. The reaction worked with easily accessible phthalimidocyclopropanes using 5 mol % $SnCl_4$ in nearly quantitative yields. Polysubstituted cyclopentyl amines, which are often present in bioactive compounds, were obtained with high diastereoselectivity and enantiospecificity. Mild conditions were also developed to access acyclic β-amino ketones and cyclopentene amines.

Catalytic Formal [3+2] Cycloaddition of Aminocyclopropanes for the Enantiospecific Synthesis of Cyclopentyl Amines. **

*Florian de Nanteuil and Jérôme Waser**

Contents

General Methods

All reactions were carried out in oven dried glassware under an atmosphere of nitrogen, unless stated otherwise. For quantitative flash chromatography technical grade solvents were used. For flash chromatography for analysis, HPLC grade solvents from Sigma-Aldrich were used. THF, Et2O, CH3CN, toluene, hexane and CH2Cl2 were dried by passage over activated alumina under nitrogen atmosphere (H2O content < 30 ppm, Karl-Fischer titration). NEt3 and pyridine were distilled under nitrogen from KOH. All chemicals were purchased from Acros, Aldrich, Fluka, VWR, Aplichem or Merck and used as such unless stated otherwise. Chromatographic purification was performed as flash chromatography using Macherey-Nagel silica 40-63, 60 Å, using the solvents indicated as eluent with 0.1-0.5 bar pressure. TLC was performed on Merck silica gel 60 F254 TLC glass plates or aluminium plates and visualized with UV light, permanganate stain, CAN stain or Anisaldehyde stain. Melting points were measured on a Büchi B-540 melting point apparatus using open glass capillaries, the data is uncorrected. 1H-NMR spectra were recorded on a Brucker DPX-400 400 MHz spectrometer in chloroform-d, DMSO-d6, CD2Cl2 or CD3OD, all signals are reported in ppm with the internal chloroform signal at 7.26 ppm, the internal DMSO signal at 2.50 ppm, the internal $CD2Cl_2$ signal at 5.31 ppm, or the internal methanol signal at 3.30 ppm as standard. The data is being reported as (s = singlet, d = doublet, t = triplet, q = quadruplet, qi = quintet, m = multiplet or unresolved, br = broad signal, coupling constant(s) in Hz, integration; interpretation). 13C-NMR spectra were recorded with 1H-decoupling on a Brucker DPX-400 100 MHz spectrometer in chloroform-d, DMSO-d6, CD2Cl2 or CD3OD, all signals are reported in ppm with the internal chloroform signal at 77.0 ppm, the internal DMSO signal at 39.5 ppm, the internal CD2Cl2 signal at 53.5 ppm or the internal methanol signal at 49.0 ppm as standard. Infrared spectra were recorded on a JASCO FT-IR B4100 spectrophotometer with an ATR PRO410-S and a ZnSe prisma and are reported as cm-1 (w = weak, m = medium, s = strong, sh = shoulder). Gas chromatographic and low resolution mass spectrometric measurements were performed on a Perkin-Elmer Clarus 600 gas chromatographer and mass spectrometer using a Perkin-Elmer Elite fused silica column (length: 30 m, diameter: 0.32 mm) and Helium as carrier gas. High resolution mass spectrometric measurements were performed by the mass spectrometry service of ISIC at the EPFL on a MICROMASS (ESI) Q-TOF Ultima API. HPLC measurement were done on a JASCO HPLC system with an AS2055 Autosampler, a PU 2089 Pump, a UV 2075 detector and a SEDEX 85 (SEDERE) detector using a CHIRALPAK IC, IB or IA column from DAICEL Chemical Industries Ltd. HPLC grade solvents from Sigma-Aldrich were used.

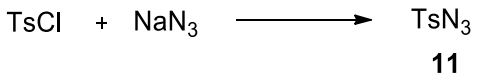
1-Phenyl-1-trimethylsiloxyethylene (5c) was purchased from Alfa Aesar [13735-81-4]

Vinyloxytrimethylsilane (5p) was purchased from Alfa Aesar [6213-94-1]

Preparation of Substrates

Synthesis of aminocyclopropane

Tosyl azide (11):

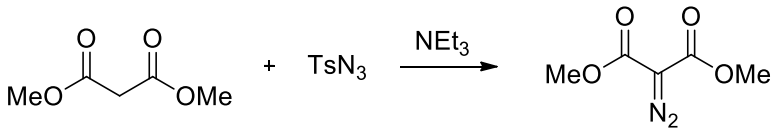


11

Following a reported procedure[1], a solution of sodium azide (10.3 g, 157 mmol, 1.5 eq) in water (60 ml) was added dropwise over 1 h to a solution of tosyl chloride (20 g, 0.11 mol, 1 eq) in acetone (200 ml) at 0°C. The reaction was allowed to warm up to 23°C and stirred for 16 h. The acetone was removed under reduced pressure at 25 °C and the reaction mixture was extracted with ether (2x 100 ml). The combined organic layers were washed with water (2 x 100 ml) , 5% Na_2CO_3 (2 x 100 ml) and water (2 x 100 ml), dried over $MgSO_4$ and the solvent was removed under reduced pressure to afford tosyl azide (20.7 g, 107 mmol, quantitative) as a colorless oil which solidify under storage at 4°C.

^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.87 (d, *J* = 8.4 Hz, 2 H, Ar H), 7.43 (d, *J* = 8.4 Hz, 2 H, Ar H), 2.51 (s, 3 H, CH_3).
The characterization data for **11** corresponded to the reported values[1]

Dimethyl 2-diazomalonate (12):



12

Following a reported procedure[2], dimethylmalonate (7.93 mL, 69.7 mmol, 1 eq), triethylamine (10.6 mL, 76.6 mmol, 1.1 eq) and tosyl azide (15.1 g, 76.6 mmol, 1.1 eq) were dissolved in acetonitrile (100 mL). The solution was stirred at 23°C for 20 h. The solution was concentrated under reduced pressure and partitioned between dichloromethane and water. The layers were separated and the aqueous layer was extracted with DCM (x1). The organic layers were combined and dried over $MgSO_4$. The crude was first filtered over a plug of silica gel (PET/Et_2O 1/1) to remove most of the tosylamide formed during the reaction. Then, purification by column chromatography (PET/Et_2O 1/1) afforded dimethyl 2-diazomalonate (10.4 g, 65.5 mmol, 94%) as a yellow oil which solidified under storage at 4°C.

R_f (PET/Et_2O 1/1) = 0.32.
^{1}H NMR (400 MHz, $CDCl_3$) δ: 3.87 (s, 1 H).
^{13}C NMR (101 MHz, $CDCl_3$) δ 161.2, 52.4[3]
The characterization data for **12** corresponded to the reported values[2]

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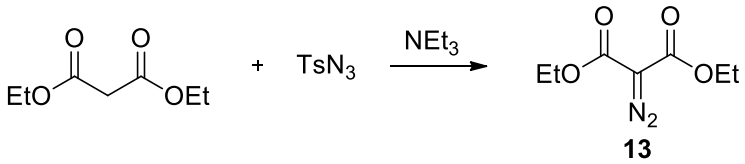
[3] The diazo carbon could not be detected

Diethyl 2-diazomalonate (13):



13

Following the procedure described below, diethylmalonate (2.17 mL, 14.3 mmol, 1 eq), triethylamine (2.18 mL, 15.7 mmol, 1.1 eq) and tosyl azide (3.09 g, 15.7 mmol, 1.1 eq) were dissolved in acetonitrile (20 mL). The solution was stirred at 23°C for 20 h. The solution was concentrated under reduced pressure and partitioned between DCM and water. The layers were separated and the aqueous layer was extracted with dichloromethane (x1). The organic layers were combined and dried over $MgSO_4$. The crude was first filtered over a plug of silica gel (PET/Et_2O 1/1) to remove most of the tosylamide formed during the reaction. Then, purification by column chromatography (PET/Et_2O 1/1) afforded dimethyl 2-diazomalonate (2.3 g, 12 mmol, 86%) as a yellow oil which solidified under storage at 4°C.

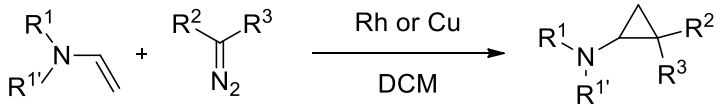
R_f (PET/Et_2O 1/1) = 0.48.

^{1}H NMR (400 MHz, $CDCl_3$) δ 4.27 (q, 4 H, *J* = 7.1 Hz), 1.28 (t, 6 H, *J* = 7.1 Hz).

^{13}C NMR (101 MHz, $CDCl_3$) δ 161.0, 61.5, 14.3[3]

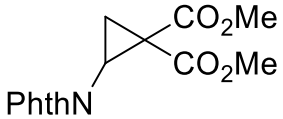
The characterization data for **13** corresponded to the reported values[4]

Cyclopropanes 4 a-f



Rhodium catalyzed cyclopropanation:

Dimethyl 2-(1,3-dioxoisoindolin-2-yl)cyclopropane-1,1-dicarboxylate (4f):



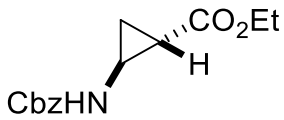
Following a modified procedure[5], bis[rhodium(α,α,α′,α′-tetramethyl-1,3-benzenedipropionic acid)] (10.9 mg, 0.014 mmol, 0.1 mol %) is weighted in the glovebox. The flask is closed with a septum and put under N_2 atmosphere. A solution of *N*-vinyl-phthalimide (2.5 g, 14 mmol, 1 eq) in 30 mL of dry dichloromethane is added and the resulting green suspension is cooled down to 0°C with an ice/water bath. A solution of dimethyl-2-diazomalonate (2.5 g, 15 mmol, 1.1 eq) in 20 mL of dichloromethane is added over five minutes. When the addition is complete, the reaction is allowed to warm to room temperature. After 5 h at room temperature, the solvent is removed under reduced pressure and the

[4] M. Kitamura, N. Tashiro, S. Miyagawa, T. Okauchi, *Synthesis*, **2011**, *7*, 1037

[5] F. Gonzalez-Bobes, M. D. B. Fenster, S. Kiau, L. Kolla, S. Kolotuchin, M. Soumeillant, *Adv. Synth. Catal.* **2008**, *350*, 813

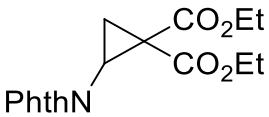
crude is directly purified by column chromatography (9:1 Hexane/Ethyl Acetate to 7:3 Hexane/Ethyl Acetate). 3.40 g (11.2 mmol, 78 % yield) of **4f** as a white solid was isolated.
The two enantiomers were separated by HPLC using Chiralpack IA column (0.46x25 cm), 95:5 Hexane/Isopropanol, 1 ml/min; tr_1 = 23.9 min, $[\alpha]_D^{25.0}$ 122 (c = 0.69, $CHCl_3$); tr_2 = 27.1 min, $[\alpha]_D^{25.0}$ -122 (c = 0.1, $CHCl_3$)
Preparative HPLC: Column IA 20x250 mm, 98:2 Hexane/Isopropanol, 16 ml/min. tr_1 = 45 min, tr_2 = 75 min
R_f 0.27 (6:4, Hexane/Ethyl acetate).
Mp 124.6-125 °C
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (m, 2 H, *Phth*), 7.75 (m, 2 H, *Phth*), 3.85 (s, 3 H, *OMe*), 3.72 (dd, 1 H, *J* = 8.5, 6.6 Hz, *N-CH*), 3.64 (s, 3 H, *OMe*), 2.73 (dd, 1 H, *J* = 6.5, 6.5 Hz, CH_2), 2.06 (dd, 1 H, *J* = 8.5, 6.4 Hz, CH_2).
^{13}C NMR (101 MHz, $CDCl_3$) δ 168.5, 167.8, 166.9, 134.3, 131.4, 123.5, 53.1, 53.0, 34.9, 33.1, 19.6.
IR 2956 (w), 1783 (w), 1727 (s), 1468 (w), 1439 (w), 1399 (m), 1329 (m), 1294 (m), 1222 (m), 1134 (w), 909 (w), 876 (w), 720 (m).
HRMS (ESI) calcd for $C_{15}H_{14}NO_6^+$ $[M+H]^+$ 304.0816; found 304.0804.

***Trans*-ethyl 2-(((benzyloxy)carbonyl)amino)cyclopropanecarboxylate (4a):**



Following the same procedure described above, using 50 mg (0.28 mmol, 1 eq) of *N*-Vinyl-*O*-benzyl Urethane[6], 64 mg (0.56 mmol, 2 eq) of Ethyl-diazoacetate and 2.1 mg (0.0028 mmol, 1 mol %) of Bis[rhodium(α,α,α′,α′-tetramethyl-1,3-benzenedipropionic acid)]. After column chromatography (100% Heptane + 1% Net_3 to 9:1 Heptane/Ethyl Acetate + 1% Net_3) 26.7 mg (0.10 mmol, 36% yield) of *trans*-product is obtained.
R_f 0.5 (7:3 Petroleum ether/Ethyl Acetate)
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.42-7.32 (m, 5 H, *Ar*), 5.13 (m, 2 H, Ar-CH_2)), 4.16 (m, 2 H, O-CH_2-CH_3, 3.12 (m, 1 H, *N-C-H*), 1.79 (m, 1 H, CH_2), 1.45 (m, 1 H, CH_2), 1.25-1.31 (t, 3 H, J= 7.5 Hz, O-CH_2-CH_3), 1.14-1.19 (m, 1 H, CH_2)
The characterization data for **4a** corresponded to the reported values [7]

Diethyl 2-(1,3-dioxoisoindolin-2-yl)cyclopropane-1,1-dicarboxylate (4d):



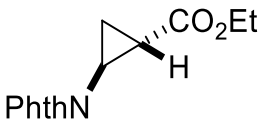
Following the same procedure described above, using 3.0 g (18 mmol, 1 eq) of *N*-vinyl-phthalimide, 4.0 g (21 mmol, 1.2 eq) of diethyl-2-diazomalonate and 14 mg (0.018 mmol, 0.1 mol %) of Bis[rhodium(α,α,α′,α′-tetramethyl-1,3-benzenedipropionic acid)], 5.4 g (16 mmol, 90 % yield) of a white solid was obtained.
R_f 0.36 (6:4, Hexane/Ethyl acetate)

[6] D. J. am Ende, K. M. DeVries, P. J. Clifford, and S. J. Brenek, *Org. Proc. Res. Dev.*, **1998**, *2*, 382
[7] J. A. Miller, E. J. Hennessy, W. J. Marshall, M. A. Scialdone, S. T. Nguyen, *J. Org. Chem.*, **2003**, *68*, 7884

Mp 93.1 °C.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (m, 2 H, *Phth*), 7.74 (m, 2 H, *Phth*), 4.30 (m, 2 H, *OCH₂*), 4.07 (m, 2 H, *OCH₂*), 3.71 (dd, 1 H, *J* = 8.5, 6.6 Hz, *N-C-H*), 2.74 (t, 1 H, *J* = 6.5 Hz, *CH₂*), 2.02 (dd, 1 H, *J* = 8.5, 6.4 Hz, *CH₂*), 1.34 (t, 3 H, *J* = 7.1 Hz, *CH₃*), 1.12 (t, 3 H, *J* = 7.1 Hz, *CH₃*).
^{13}C NMR (101 MHz, $CDCl_3$) δ 168.2, 167.8, 166.4, 134.3, 131.6, 123.4, 62.0, 61.8, 34.7, 33.5, 19.2, 14.1, 13.8.
IR 2985 (w), 2938 (w), 2907 (w), 1783 (m), 1719 (s), 1614 (w), 1393 (s), 1321 (m), 1218 (s), 1133 (m), 719 (s).
HRMS (ESI) calcd for $C_{17}H_{18}NO_6^+$ $[M+H]^+$ 332.1129; found 332.1135

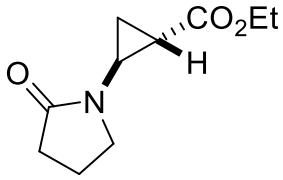
Copper catalyzed cyclopropanation

***Trans*-ethyl 2-(1,3-dioxoisoindolin-2-yl)cyclopropanecarboxylate (4e):**



copper-(I)-trifluoromethanesulfonate-toluene complex (26.4 mg, 0.0510 mmol, 2.5 mol %) is weighted in the glovebox. The flask is closed with a septum, protected from light and put under N_2 atmosphere. A solution of *N*-vinyl-phthalimide (500 mg, 2.04 mmol, 1 eq) in 4 mL of dry dichloromethane is added. Ethyl diazoacetate (0.860 ml, 8.16 mmol, 4 eq) is added via a syringe pump over 18 h. When the addition is complete, the solvent is removed under reduced pressure and the crude is directly purified by column chromatograpy (8:2 Petroleum Ether/Ethyl Acetate). The isolated yellow solid is recrystallized in Petroleum Ether/Ethyl Acetate to give 205 mg (0.791 mmol, 40 % yield) of the *trans* cyclopropane as a colorless solid.
R_f 0.36 (8:2, Petroleum Ether/Ethyl acetate).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87-7.81 (m, 2 H, *Phth*), 7.77-7.71 (m, 2 H, *Phth*), 4.22 (q, 2 H, *J* = 7.2 Hz, O-C*H₂*-CH_3), 3.35-3.28 (m, 1 H, *N-C-H*), 2.25-2.20 (m, 1 H, C*H*CO_2Et), 1.76 (dt, 1 H, *J* = 9.3, 5.5 Hz, C*H₂*), 1.65 (dt, 1 H, *J* = 8.1, 5.9 Hz, C*H₂*), 1.32 (t, 3 H, *J* = 7.2 Hz, O-CH_2-C*H₃*).
^{13}C NMR (101 MHz, $CDCl_3$) δ 172.1, 168.0, 134.3, 131.6, 123.4, 61.1, 29.5, 20.0, 14.2, 13.6
The characterization data for **4b** corresponded to the reported values[8]

***Trans*-ethyl 2-(2-oxopyrrolidin-1-yl)cyclopropanecarboxylate (4b):**

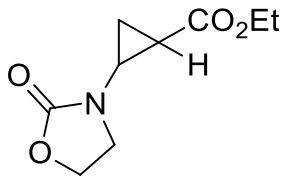


Following the same procedure described above, using 250 mg (2.25 mmol, 1 eq) of commercially available *N*-vinyl-pyrrolidone [88-12-0], 0.95 mL (8.9 mmol, 4 eq) of ethyl diazoacetate and 29 mg (0.056 mmol, 2.5 mol %) of copper-(I)-trifluoromethanesulfonate-toluene complex, 240 mg (1.22

[8] A. Abu-Elfotoh, K. Phomkeona, K. Shibatomi, S. Iwasa, *Angew. Chem. Int. Ed.* **2010**, *49*, 8439 –8443

mmol, 54 % yield) of a yellow oil is obtained after column chromatography purification (9/1 Petroleum Ether/Ethyl Acetate to 100 Ethyl Acetate).
R_f 0.2 (Ethyl acetate).
^{1}H NMR (400 MHz, $CDCl_3$) δ 4.15 (qd, 2 H, *J* = 7.2, 1.5 Hz, O-C*H*$_2$-CH_3), 3.31 (t, 2 H, *J* = 7.2 Hz, C*H*$_2$ pyrrolidone), 3.20-3.15 (m, 1 H, *N-C-H*), 2.39 (t, 2 H, *J* = 8.0 Hz, C*H*$_2$ pyrrolidone), 2.05-1.96 (m, 2 H, C*H*$_2$ pyrrolidone), 1.88-1.82 (m, 1 H, C*H*CO_2Et), 1.51-1.38 (m, 2 H, C*H*$_2$), 1.27 (t, 3 H, *J* = 7.1 Hz, O-CH_2-C*H*$_3$).
^{13}C NMR (101 MHz, $CDCl_3$) δ 175.9, 172.3, 60.9, 47.2, 34.1, 31.7, 19.7, 18.0, 14.2, 14.1.
The characterization data for **4b** corresponded to the reported values [8]

Ethyl 2-(2-oxooxazolidin-3-yl)cyclopropanecarboxylate (4c):

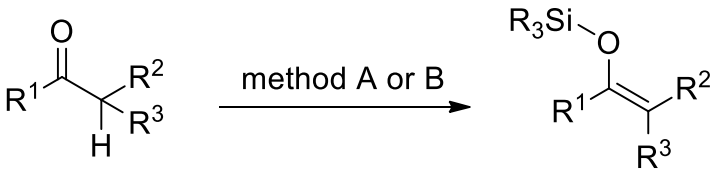


Following the same procedure described above, using 2.42 g (21.4 mmol, 1 eq) of *N*-vinyl-oxazolidinone[9], 9.0 mL (86 mmol, 4 eq) of ethyl diazoacetate and 277 mg (0.534 mmol, 2.5 mol %) of copper-(I)-trifluoromethanesulfonate-toluene complex, 3.21 g (16.1 mmol, 75 % yield) of a yellow oil is obtained after column chromatography purification (9/1 Petroleum Ether/Ethyl Acetate to 100 Ethyl Acetate).
1:1 Mixture of *cis* and *trans* non-separable diastereomers.
R_f 0.3 (98:2 DCM/MeOH).
^{1}H NMR (400 MHz, $CDCl_3$) δ 4.35-4.26 (m, 4 H, C*H*$_2$ oxazolidinone), 4.19-4.11 (m, 4 H, O-C*H*$_2$-CH_3), 3.74 (dd, 1 H, *J* = 7.9, 7.9 Hz, *N-C-H*), 3.60-3.50 (m, 3 H, *N-C-H* and C*H*$_2$ oxazolidinone), 3.07-3.00 (m, 2 H, C*H*$_2$ oxazolidinone), 2.02 (m, 1 H, C*H*CO_2Et), 1.90 (m, 1 H, C*H*CO_2Et), 1.55 (q, 1 H, *J* = 6.0 Hz, C*H*$_2$), 1.52-1.43 (m, 2 H, C*H*$_2$), 1.38-1.31 (m, 1 H, C*H*$_2$), 1.30-1.24 (m, 6 H, O-CH_2-C*H*$_3$).
^{13}C NMR (101 MHz, $CDCl_3$) δ 171.9, 170.5, 158.5, 157.9, 62.3, 61.9, 61.0, 61.0, 45.7, 45.7, 34.4, 33.0, 20.7, 20.6, 15.0, 14.2, 12.8[10]
IR 2986 (w), 2985 (w), 2917 (w), 1751 (s), 1723 (s), 1722 (s), 1426 (m), 1409 (m), 1185 (s), 1040 (m).
HRMS (ESI) calcd for C9H14NO4+ [M+H]+ 200.0917; found 200.0908

[9] Prepared following the reported procedure: *Org. Lett*. **2004**, *6*, 1845
[10] One carbon aliphatic of one diastereomer could not be resolved

Synthesis of Silyl Enol Ethers

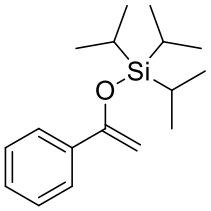
General procedure for the synthesis of Silyl Enol Ethers:



Method A:
The ketone (1 eq) in anhydrous THF is added in an oven-dried flask sealed with a septum and under N_2 atmosphere. The solution is cooled down to -78 °C and a 2 M solution of NaHMDS (1.22 eq) is added dropwise. The cold bath is removed and the pale yellow solution is stirred for 1 hour at room temperature. The reaction is cooled again at -78 °C and the corresponding silyl chloride (1.2 eq) is added dropwise. The reaction is stirred at room temperature for 5 hours after what the solvent is directly removed under reduced pressure. The resulting orange oil is purified by plug or by column chromatography on triethylamine-deactivated silica (100 % Hexane).

Method B:
The ketone (1 eq) in anhydrous dichloromethane is added in an oven-dried flask sealed with a septum and under N_2 atmosphere . Triethylamine (1.8 eq) and then triisopropylsilyl-trifluoromethanesulfonate (1.2 eq) are added at room temperature. After two hours, the reaction is diluted with dichloromethane and washed with a solution of sat. NH_4Cl. The aqueous layer is extracted three times with ethyl acetate. The organic layers are collected, washed with brine, dried over anhydrous sodium sulfate, filtered and concentrated under reduced pressure. The crude oil is purified by plug or column chromatography on triethylamine deactivated silica (100 % Hexane).

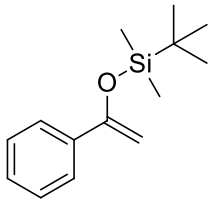
Triisopropyl((1-phenylvinyl)oxy)silane (5a):



Using method A, starting from 580 mg of acetophenone (4.82 mmol), 1.03 g (3.72 mmol, 77 % yield) of a colorless oil was obtained.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69-7.65 (m, 2 H, *Ar*), 7.38-7.29 (m, 3 H, *Ar*), 4.85 (d, 1 H, *J* = 1.8 Hz, C=C*H*$_2$), 4.41 (d, 1 H, *J* = 1.8 Hz, C=C*H*$_2$), 1.39-1.27 (m, 3 H, SiC*H*$(CH_3)_2$), 1.19-1.13 (m, 18 H, SiCH(C*H*$_3)_2$).
^{13}C NMR (101 MHz, $CDCl_3$) δ 156.2, 138.0, 128.2, 128.1, 125.4, 90.0, 18.2, 12.9
The characterization data for **5a** corresponded to the reported values[11]

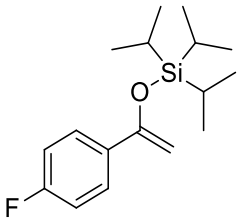
[11] Jun-Feng Zhao, Boon-Hong Tan and Teck-Peng Loh *Chem. Sci*. **2011**, *2*, 349

tert-Butyldimethyl((1-phenylvinyl)oxy)silane (5b):



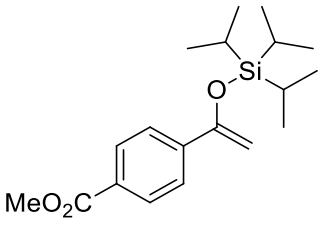
Using method A, starting from 580 mg of acetophenone (4.82 mmol), 960 mg (4.10 mmol, 85 % yield) of a colorless oil was obtained.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65-7.60 (m, 2 H, *Ar*), 7.39-7.29 (m, 3 H, *Ar*), 4.89 (d, 1 H, *J* = 1.7 Hz, C=CH_2), 4.42 (d, 1 H, *J* = 1.7 Hz, C=CH_2), 1.00 (s, 9 H, Si(CH_3)$_2$*C*(CH_3)$_3$), 0.21 (s, 5 H, Si(CH_3)$_2$C(CH_3)$_3$).
^{13}C NMR (101 MHz, $CDCl_3$) δ 156.0, 137.8, 128.2, 128.1, 125.3, 90.9, 25.9, 18.4, -4.6.
The characterization data for **5b** corresponded to the reported values[11]

((1-(4-Fluorophenyl)vinyl)oxy)triisopropylsilane (5d):



Using method B, starting from 500 mg of 4'-Fluoroacetophenone (3.62 mmol), 776 mg (2.64 mmol, 73 % yield) of a colorless oil were obtained.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (m, 2 H, *Ar*), 7.00 (m, 2 H, *Ar*), 4.77 (d, 1 H, *J* = 2.0 Hz, C=CH_2), 4.39 (d, 1 H, *J* = 1.9 Hz, C=CH_2), 1.43-1.29 (m, 3 H, SiC*H*(CH_3)$_2$), 1.22-1.14 (m, 18 H, SiCH(*C*H_3)$_2$).
^{13}C NMR (101 MHz, $CDCl_3$) δ 162.8 (d, *J* = 248 Hz), 155.3, 134.1 (d, *J* = 3 Hz), 127.1 (d, *J* = 8.1 Hz), 114.9 (d, *J* = 21.5 Hz), 89.7 (d, *J* = 2 Hz), 18.1, 12.8.
The characterization data for **5d** corresponded to the reported values[11]

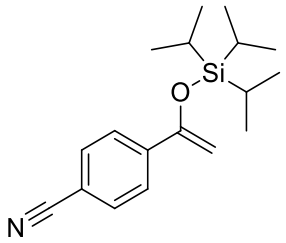
Methyl 4-(1-((triisopropylsilyl)oxy)vinyl)benzoate (5e):



Using method B, starting from 500 mg of methyl 4-acetylbenzoate (2.81 mmol), 856 mg (2.56 mmol, 91 % yield) of a colorless oil were obtained.
R_f 0.5 (9:1, Hexane/Ethyl acetate).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (m, 2 H, *Ar*), 7.70 (m, 2 H, *Ar*), 4.96 (d, 1 H, *J* = 2.0 Hz, C=CH_2), 4.53 (d, 1 H, *J* = 2.0 Hz, C=CH_2), 3.92 (s, 3 H, CO_2C*H*$_3$), 1.37-1.26 (m, 3 H, SiC*H*(CH_3)$_2$), 1.18-1.12 (m, 18 H, SiCH(*C*H_3)$_2$).

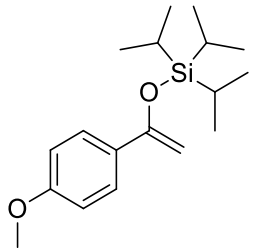
^{13}C NMR (101 MHz, $CDCl_3$) δ 166.9, 155.3, 142.3, 129.6, 129.5, 125.2, 92.1, 52.1, 18.1, 12.8
IR 3669 (w), 3522 (w), 2959 (m), 2955 (m), 2943 (m), 2867 (m), 1722 (s), 1679 (m), 1282 (s), 1113 (s)
HRMS (ESI) calcd for $C_{19}H_{31}O_3Si^+$ $[M+H]^+$ 335.2037; found 335.2032

4-(1-((Triisopropylsilyl)oxy)vinyl)benzonitrile (5f):



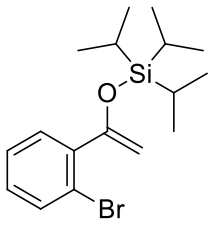
Using method B, starting from 0.50 mg of 4-Acetylbenzonitrile (3.4 mmol), 1.0 g (3.3 mmol, 97 % yield) of a pale orange oil were obtained.
R_f 0.55 (9:1, Hexane/Ethyl acetate).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (m, 2 H, *Ar*), 7.62 (m, 2 H, *Ar*), 4.96 (d, 1 H, *J* = 2.3 Hz, C=CH_2), 4.57 (d, 1 H, *J* = 2.3 Hz, C=CH_2), 1.39-1.26 (m, 3 H, SiC*H*$(CH_3)_2$), 1.18-1.12 (m, 18 H, SiCH$(CH_3)_2$).
^{13}C NMR (101 MHz, $CDCl_3$) δ 154.5, 142.2, 132.0, 125.8, 119.0, 111.5, 92.8, 18.1, 12.7.
IR 2946 (m), 2945 (m), 2892 (w), 2868 (m), 2229 (w), 1614 (w), 1464 (w), 1317 (s), 1302 (m), 1111 (s), 1015 (s).
HRMS (ESI) calcd for $C_{18}H_{28}NOSi^+$ $[M+H]^+$ 302.1935; found 302.1935.

Triisopropyl((1-(4-methoxyphenyl)vinyl)oxy)silane (5g):



Using method A, starting from 724 mg of 4'-methoxyacetophenone (4.82 mmol), 1.3 g (4.2 mmol, 91 % yield) of a colorless oil were obtained.
R_f 0.75 (9:1, Hexane/Ethyl acetate).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 (m, 2 H, *Ar*), 6.92 (m, 2 H, *Ar*), 4.81 (d, 1 H, *J* = 1.8 Hz, C=CH_2), 4.39 (d, 1 H, *J* = 1.8 Hz, C=CH_2), 3.86 (s, 3 H, OCH_3), 1.43-1.31 (m, 3 H, SiC*H*$(CH_3)_2$), 1.23-1.17 (m, 18 H, SiCH$(CH_3)_2$).
^{13}C NMR (101 MHz, $CDCl_3$) δ 159.7, 155.9, 130.7, 126.7, 113.4, 88.4, 55.2, 18.2, 12.9.
IR 2944 (w), 2891 (w), 2867 (m), 2838 (w), 1608 (m), 1510 (s), 1464 (m), 1249 (s), 1175 (s), 1014 (s), 734 (s).
HRMS (ESI) calcd for $C_{18}H_{31}O_2Si^+$ $[M+H]^+$ 307.2088; found 307.2076

((1-(2-Bromophenyl)vinyl)oxy)triisopropylsilane (5h):



Using method A, starting from 0.50 ml of 2'-Bromoacetophenone (3.7 mmol), 1.15 g (3.26 mmol, 88 % yield) of a colorless oil were obtained.

R_f 0.80 (9:1, Hexane/Ethyl acetate).

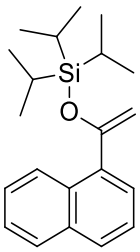
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 (ddd, 1 H, J = 8.0, 1.2, 0.2 Hz, *Ar*), 7.46 (dd, 1H, J = 7.6, 1.8 Hz, *Ar*), 7.29 (td, 1 H, J = 7.4, 1.3 Hz, *Ar*), 7.16 (ddd, 1 H, J = 8.0, 7.4, 1.8 Hz, *Ar*), 4.63 (d, 1 H, *J* = 1.5 Hz, C=CH_2), 4.55 (d, 1 H, *J* = 1.5 Hz, C=CH_2), 1.32-1.21 (m, 3H, SiC*H*$(CH_3)_2$), 1.16-1.11 (m, 18 H, SiCH(CH_3)$_2$).

^{13}C NMR (101 MHz, $CDCl_3$) δ 156.2, 140.5, 133.3, 130.3, 129.1, 126.9, 121.5, 95.4, 18.1, 12.7.

IR 2945 (w), 2891 (w), 2866 (m), 1705 (w), 1626 (w), 1589 (w), 1466 (m), 1317 (s), 1024 (s), 883 (m).

HRMS (ESI) calcd for $C_{17}{}^{79}BrH_{28}OSi^+$ $[M+H]^+$ 355.1087; found 355.1075

Triisopropyl((1-(naphthalen-1-yl)vinyl)oxy)silane (5i):



Using method B, starting from 500 mg of 1'-acetonaphthone (2.94 mmol), 865 mg (2.65 mmol, 91 % yield) of a colorless oil were obtained.

R_f 0.66 (100% Hexane).

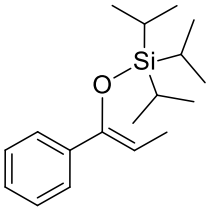
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.42-8.37 (m, 1 H, *Ar*), 7.88-7.80 (m, 2 H, *Ar*), 7.59-7.40 (m, 4 H, *Ar*), 4.76 (d, 1 H, *J* = 0.8 Hz, C=CH_2), 4.63 (d, 1 H, *J* = 0.8 Hz, C=CH_2), 1.30-1.17 (m, 3 H, SiC*H*$(CH_3)_2$), 1.12-1.05 (m, 18 H, SiCH(CH_3)$_2$).

^{13}C NMR (101 MHz, $CDCl_3$) δ 157.6, 137.7, 133.7, 131.0, 128.4, 128.1, 126.6, 125.9, 125.8, 125.7, 125.0, 95.9, 18.0, 12.7.

IR 2944 (m), 2892 (w), 2866 (m), 1626 (w), 1615 (w), 1464 (w), 1304 (s), 1016 (s), 778 (s).

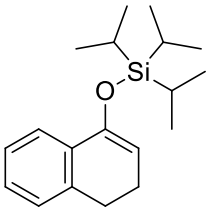
HRMS (ESI) calcd for $C_{21}H_{31}OSi^+$ $[M+H]^+$ 327.2139; found 327.2132.

(Z)-Triisopropyl((1-phenylprop-1-en-1-yl)oxy)silane (5j):



Using method A, starting from 500 mg of propiophenone (11.2 mmol), 3.2 g (11 mmol, 98 % yield) of a colorless oil were obtained.
R_f 0.85 (9:1, Hexane/Ethyl acetate).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53-7.47 (m, 2 H, *Ar*), 7.36-7.25 (m, 3 H, *Ar*), 5.06 (q, 1 H, J = 6.9 Hz, C=CH_2), 1.85-1.80 (d, 3 H, *J* = 6.9 Hz, CH_3), 1.19-1.05 (m, 21 H, TIPS).
^{13}C NMR (101 MHz, $CDCl_3$) δ 151.3, 140.4, 127.9, 127.3, 126.0, 105.2, 18.0, 13.6, 11.8.
IR 3058 (w), 2945 (s), 2918 (m), 2867 (s), 1694 (m), 1653 (w), 1464 (m), 1325 (s), 1080 (s), 1064 (s), 883 (s).
HRMS (ESI) calcd for $C_{18}H_{31}OSi^+$ $[M+H]^+$ 291.2139; found 291.2145.

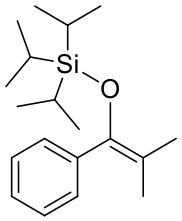
((3,4-Dihydronaphthalen-1-yl)oxy)triisopropylsilane (5k):



Using method A, starting from 540 mg of alpha-tetralone (3.69 mmol), 973 mg (3.22 mmol, 87 % yield) of a colorless oil were obtained.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58 (dd, J = 7.4, 1.0 Hz, *Ar*), 7.29-7.12 (m, 3 H, *Ar*), 5.18 (t, 1 H, *J* = 4.6 Hz, C=C*H*), 2.76 (t, 2 H, *J* = 7.7 Hz, Ar-CH_2), 2.37-2.29 (m, 2 H, Ar-CH_2-CH_2), 1.37-1.26 (m, 3 H, SiC*H*$(CH_3)_2$), 1.19-1.13 (m, 18 H, SiCH(CH_3)$_2$).
^{13}C NMR (101 MHz, $CDCl_3$) δ 148.5, 137.2, 133.8, 127.2, 126.9, 126.2, 122.0, 103.8, 28.3, 22.3, 18.2, 12.9.
The characterization data for **11** corresponded to the reported values[12]

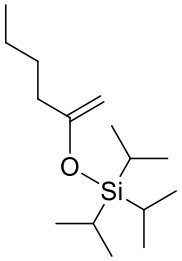
[12] L. Zhang, J. Sun, S. A. Kozmin, *Tetrahedron*, **2006**, *62*, 11371

Triisopropyl((2-methyl-1-phenylprop-1-en-1-yl)oxy)silane (5l):



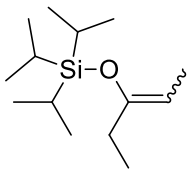
Using method A, starting from 548 mg of propiophenone (3.70 mmol), 1.1 g (3.6 mmol, 98 % yield) of a colorless oil were obtained.
R_f 0.85 (9:1, Hexane/Ethyl acetate).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39-7.25 (m, 5 H, *Ar*), 1.88 (s, 3 H, C*H*$_3$), 1.63 (s, 3 H, C*H*$_3$), 1.08-0.96 (m, 21 H, TIPS)
^{13}C NMR (101 MHz, $CDCl_3$) δ 144.2, 139.4, 129.5, 127.6, 127.2, 111.6, 20.0, 18.2, 17.9, 13.2
IR 2966 (m), 2962 (m), 2960 (m), 2945 (m), 2924 (m), 2867 (m), 1671 (w), 1464 (w), 1162 (s), 832 (s)
HRMS (ESI) calcd for $C_{19}H_{33}OSi^+$ $[M+H]^+$ 305.2295; found 305.2308.

(Hex-1-en-2-yloxy)triisopropylsilane (5m):



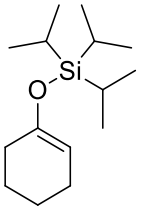
Using method A, starting from 370 mg of 2-hexanone (3.69 mmol), 873 mg (3.40 mmol, 92 % yield) of a colorless oil were obtained containing a 10:1.3:0.3 mixture of the di- and Z/E trisubstituted isomers.
Major Isomer:
Rf 0.75 (9:1, Hexane/Ethyl acetate)
^{1}H NMR (400 MHz, CDCl3) δ 4.03 (s, 1 H, C=C*H*$_2$), 4.00 (s, 1 H, C=C*H*$_2$), 2.08 (m, 2 H, C-CH_2), 1.51 (m, 2 H, -C*H*$_2$-), 1.37 (m, 2 H, -C*H*$_2$-), 1.27-1.16 (m, 3 H, SiC*H*$(CH_3)_2$), 1.16-1.08 (m, 18 H, SiCH(*CH*$_3$)$_2$), 0.93 (t, 3 H, J = 7.3 Hz, -C*H*$_3$).
^{13}C NMR (101 MHz, $CDCl_3$) δ 159.9, 88.6, 36.4, 29.2, 22.3, 18.0, 14.0, 12.7.
IR 2945 (s), 2895 (w), 2868 (s), 1674 (w), 1657 (w), 1617 (w), 1464 (m), 1272 (s), 1020 (s), 883 (s)
HRMS (ESI) calcd for $C_{15}H_{33}OSi^+$ $[M+H]^+$ 257.2295; found 257.2308.

Triisopropyl(pent-2-en-3-yloxy)silane (5n):



Using method A, starting from 318 mg of 3-pentanone (3.69 mmol), 549 mg (2.26 mmol, 61 % yield) of a colorless oil were obtained containing a 8.3:1 mixture of Z/E isomers.
^{1}H NMR (400 MHz, $CDCl_3$) δ 4.56 (q, 0.12 H, *J* = 6.9 Hz, C=C*H* E isomer), 4.46 (qt, J = 6.5, 1.0 Hz, C=C*H* Z isomer), 2.16-2.07 (m, 2.2 H, CH_2 Z+E isomers), 1.64-1.59 (m, 3 H, CHCH_3 Z isomer), 1.57-1.54 (d, 0.4 H, *J* = 6.8 Hz, E isomer), 1.25-1.02 (m, 27 H, TIPS + CH_2CH_3 Z+E isomers).
^{13}C NMR (101 MHz, $CDCl_3$) (only Z isomer) δ 153.2, 99.4, 29.4, 18.1, 13.3, 11.8, 10.7.
The characterization data for **5n** corresponded to the reported values[13]

(Cyclohex-1-en-1-yloxy)triisopropylsilane (5o):

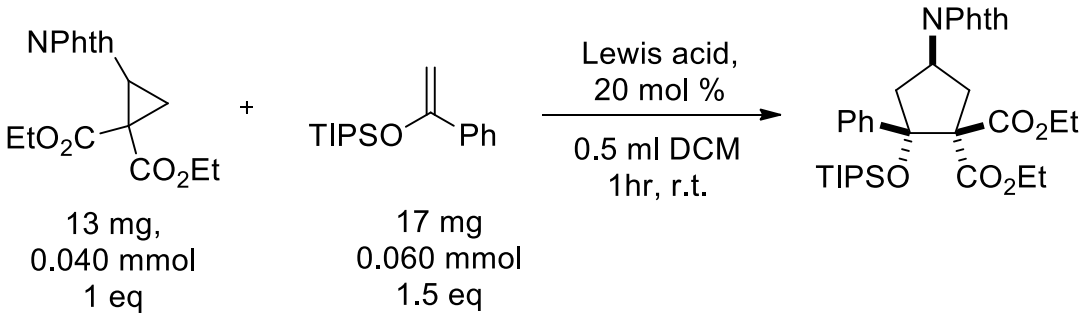


Using method A, starting from 474 mg of cyclohexanone (4.82 mmol), 1.22 g (4.82 mmol, 100 % yield) of a colorless oil were obtained.
^{1}H NMR (400 MHz, $CDCl_3$) δ 4.88 (m, 1 H, C=C*H*), 2.11-1.99 (m, 4 H, -CH_2-), 1.72-1.64 (m, 2 H, -CH_2-), 1.57-1.50 (m, 2 H, -CH_2-), 1.22-1.04 (m, 21 H, *TIPS*)
^{13}C NMR (101 MHz, $CDCl_3$) δ 150.6, 103.6, 30.0, 23.9, 23.3, 22.4, 18.0, 12.7.
The characterization data for **5o** corresponded to the reported values[14]

[13] P. Magnus, L. Barth, *Tetrahedron*, 1995, 51, 11075
[14] J. Q. Yu, H. C. Wu, E. J. Corey, *Org. Lett.* **2005**, *7*, 1415

Scope of the Reaction

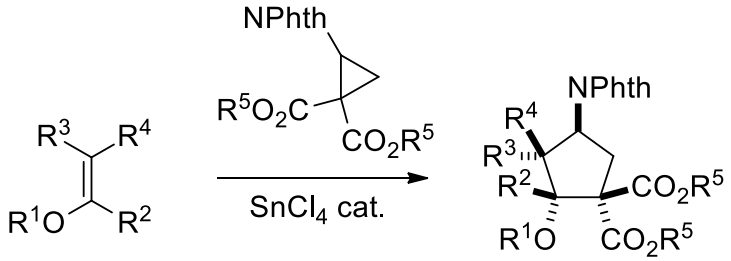
Complete optimization table



Acid	Conversion %	Closed/Open
$SnCl_4$	100.00[a]	>100/1
$SnCl_4$	100.00	1/1
$Cu(OTf)_2$	100.00	5/1
$(CuOTf)_2$.Tol	100.00	1/1
$In(Otf)_3$	100.00	>1/100
$AlCl_3$	100.00	0.4/1
$Sn(Otf)_2$	100.00	2/1
$Yb(Otf)_3$	100.00	5/1
$HNTf_2$	100.00	>1/100
$Sc(Otf)_3$	100.00	1/3
$Hf(Otf)_4$	100.00	1/2
$Zn(NTf)_2$	100.00	1/2,5
$Zn(OTf)_2$	40.00	0.5/1
$Ni(ClO_4)_2$	30.00	>10/1
$CuCl_2$	0	nd
AgOTf	0	nd
Me_2AlCl	0	nd
MgI_2	0	nd
H_3PO_4	0	nd
Camphorsulfonic acid	0	nd
Trifluoroacetic acid	0	nd
$BF_3.OEt_2$	0	nd
Bn_2BOTf	0	nd

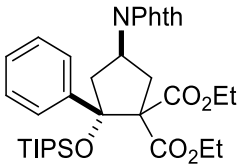
a: reaction at -78 °C

General procedure for the $SnCl_4$-catalyzed synthesis of *N*-phthalimide aminocyclopentane :



In an oven-dried flask sealed with a septum and under N_2 atmosphere is added the N-phthalimide aminocyclopropane (0.3 mmol, 1 eq) and the silyl-enol ether (1.5 eq) in dry dichloromethane (0.15 M). The solution is cooled down to -78 °C and a 0.43 M solution of tin tetrachloride (5 mol %) in dry dichloromethane is added. The reaction is stirred for 1 h at -78 °C. Triethylamine (0.2 mL) is then added in one portion at -78 °C. The reaction is warmed at room temperature and stirred for 15 min. Dichloromethane is removed under reduced pressure and the crude is directly purified by column chromatography (8:2 Hexane/Ethyl Acetate).

Trans-Diethyl-4-(1,3-dioxoisoindolin-2-yl)-2-phenyl-2-((triisopropylsilyl)oxy)cyclopentane-1,1-dicarboxylate (6da):



Using the method described above, 180 mg (0.296 mmol, 98%) of a single diastereomer as a colorless solid was obtained.

Rf 0.54 (7:3, Hexane/Ethyl acetate).

Mp 113.4 °C.

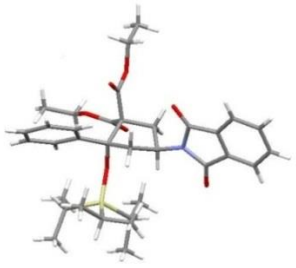
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90-7.81 (m, 4 H, *Phth + Ar*), 7.74 (m, 2 H, *Phth*), 7.33-7.26 (m, 3 H, *Ar*), 5.30 (m, 1 H, *N-C-H*), 4.33 (m, 2 H, CO_2CH_2), 4.00-3.81 (m, 3 H, CO_2CH_2+ CH_2), 3.42 (ddd, 1 H, *J* = 13.6, 9.5, 1.1 Hz, CH_2), 2.89 (dd, 1 H, *J* = 13.7, 8.9 Hz, CH_2), 2.46 (ddd, 1 H, J = 12.3, 6.0, 1.0 Hz, CH_2), 1.36 (t, 3H, *J* = 7.1 Hz, CH_3), 1.03-0.92 (m, 24 H, CH_3 + *TIPS*)

^{13}C NMR (101 MHz, $CDCl_3$) δ 170.6, 168.4, 168.3, 142.0, 134.0, 132.0, 128.6, 127.9, 127.1, 123.2, 87.5, 70.1, 61.5, 61.0, 47.9, 41.8, 36.3, 18.2, 18.2, 13.7[15]

IR 2944 (w), 2868 (w), 2258 (w), 1775 (w), 1734 (m), 1712 (s), 1377 (s), 1253 (m), 1128 (s), 981 (m)

HRMS (ESI) calcd for $C_{34}H_{46}NO_7Si^+$ $[M+H]^+$ 608.3038; found 608.3050

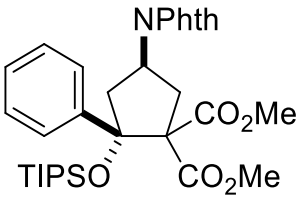
Recrystallized in ethanol.



[15] The CH_3 carbons of TIPS are splitting.

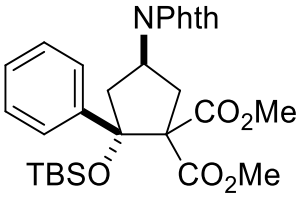
The crystal structure has been deposited at the Cambridge Crystallographic Data Centre and allocated the deposition number : CCDC 842232

Trans-Dimethyl-4-(1,3-dioxoisoindolin-2-yl)-2-phenyl-2-((triisopropylsilyl)oxy)cyclopentane-1,1-dicarboxylate (6fa):



Using the method described above, 165 mg (0.284 mmol, 95%) of a single diastereomer as a colorless solid was obtained.
The two enantiomers were separated by HPLC using Chiralpack IA column (0.46x25 cm), 95:5 Hexane/Isopropanol, 0.5 ml/min; tr_1 = 20.0 min, $[\alpha]_D^{25.0}$ - 40.3 (c = 1, $CHCl_3$); tr_2 = 21.4 min,
R_f 0.55 (6:4, Hexane/Ethyl acetate).
Mp 134.5 °C.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 (m, 2H, *Phth*), 7.80-7.72 (m, 4 H, *Phth* + *Ar*), 7.34-7.25 (m, 3 H, *Ar*), 5.29 (m, 1 H, *N-C-H*), 3.86 (s, 3 H, *OMe*), 3.81 (t, 1 H, *J* = 12.2 Hz, *CH_2*), 3.47-3.39 (m, 4 H, *OMe* + *CH_2*), 2.91 (dd, 1 H, *J* = 13.7, 8.7 Hz, *CH_2*), 2.46 (dd, 1 H, *J* = 12.4, 6.2 Hz, *CH_2*), 1.01-0.92 (m, 21 H, *TIPS*).
^{13}C NMR (101 MHz, $CDCl_3$) δ 171.0, 168.7, 168.4, 141.8, 134.1, 132.0, 128.4, 128.0, 127.1, 123.2, 87.6, 70.1, 52.4, 52.1, 47.8, 41.7, 36.2, 18.2, 18.2, 13.7[15]
IR 2952 (w), 2868 (w), 2259 (w), 1738 (m), 1712 (s), 1378 (m), 1129 (s), 981 (m).
HRMS (ESI) calcd for $C_{32}H_{42}NO_7Si^+$ $[M+H]^+$ 580.2725; found 580.2717.

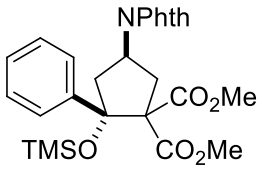
Trans-Dimethyl-2-((tert-butyldimethylsilyl)oxy)-4-(1,3-dioxoisoindolin-2-yl)-2-phenylcyclopentane-1,1-dicarboxylate (6fb):



Using the method described above, 157 mg (0.293 mmol, 98%) of a single diastereomer as a colorless solid was obtained.
R_f 0.38 (7:3, Hexane/Ethyl acetate).
Mp 162.9 °C.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (m, 2 H, *Phth*), 7.79-7.68 (m, 4 H, *Phth* + *Ar*), 7.36-7.26 (m, 3 H, *Ar*), 5.27 (m, 1 H, *N-C-H*), 3.87 (s, 3 H, *OMe*), 3.78 (dd, 1 H, *J* = 12.2, 12.2 Hz, *CH_2*), 3.47 (s, 3 H, *OMe*), 3.41 (ddd, 1 H, *J* = 13.5, 9.3, 1.2 Hz, *CH_2*), 2.93 (dd, 1 H, *J* = 13.6, 8.9 Hz, *CH_2*), 2.36 (dd, 1H, J = 12.0, 5.0 Hz, *CH_2*), 0.95 (s, 9 H, *TBS*), 0.04 (s, 3 H, *TBS*), -0.47 (s, 3 H, *TBS*).
^{13}C NMR (101 MHz, $CDCl_3$) δ 170.9, 168.7, 168.3, 141.3, 134.1, 132.0, 128.4, 127.9, 127.2, 123.2, 87.1, 69.8, 52.4, 52.1, 47.7, 41.7, 36.2, 25.8, 18.5, -2.5, -3.5.

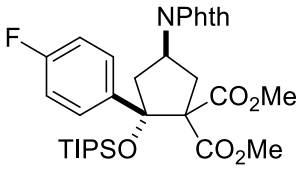
IR 2953 (w), 2932 (w), 2887 (w), 2857 (w), 2258 (w), 1737 (m), 1712 (s), 1378 (m), 1128 (m), 909 (s).
HRMS (ESI) calcd for $C_{29}H_{36}NO_7Si^+$ $[M+Na]^+$ 560.2075; found 560.2012.

***Trans*-Dimethyl-4-(1,3-dioxoisoindolin-2-yl)-2-phenyl-2-((trimethylsilyl)oxy)cyclopentane-1,1-dicarboxylate (6fc)**:



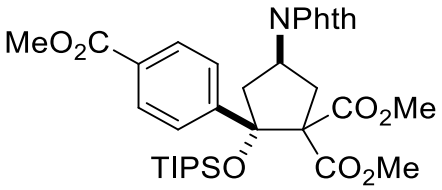
Using the method described above, 141 mg (0.285 mmol, 95%) of a single diastereomer as a colorless solid was obtained.
R_f 0.35 (7:3, Hexane/Ethyl acetate).
Mp 139.5 °C.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 (m, 2 H, *Phth*), 7.76 (m, 2 H, *Phth*), 7.69-7.65 (m, 2 H, *Ar*), 7.35-7.27 (m, 3 H, *Ar*), 5.23 (m, 1 H, *N-C-H*), 3.85 (s, 3 H, *OMe*), 3.80 (t, 1 H, *J* = 12.2 Hz, *CH_2*), 3.49 (s, 3 H, *OMe*), 3.36 (ddd, 1 H, *J* = 13.5, 9.3, 1.4 Hz, *CH_2*), 2.93 (dd, 1 H, *J* = 13.6, 9.0 Hz, *CH_2*), 2.28 (ddd, 1 H, *J* = 12.2, 5.9, 1.2 Hz, *CH_2*), -0.03 (s, 9 H, *TMS*).
^{13}C NMR (101 MHz, $CDCl_3$) δ 170.7, 168.9, 168.4, 141.3, 134.1, 132.0, 128.2, 127.8, 127.2, 123.2, 87.2, 69.8, 52.2, 52.1, 47.9, 41.6, 35.8, 1.6.
IR 2953 (w), 2924 (w), 2850 (w), 1773 (w), 1738 (s), 1712 (s), 1379 (m), 1253 (m), 1131 (m), 985 (m), 845 (s).
HRMS (ESI) calcd for $C_{26}H_{30}NO_7Si^+$ [M+H]+ 496.1786; found 496.1800

***Trans*-Dimethyl-4-(1,3-dioxoisoindolin-2-yl)-2-(4-fluorophenyl)-2-((triisopropylsilyl)oxy)cyclo-pentane-1,1-dicarboxylate (6fd):**



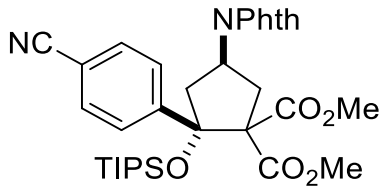
Using the method described above, 163 mg (0.273 mmol, 91%) of a single diastereomer as a colorless solid was obtained.
R_f 0.6 (6:4, Hexane/Ethyl acetate).
Mp 152.5 °C.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (m, 2 H, *Phth*), 7.79-7.73 (m, 4 H, *Phth* + *Ar*), 7.00 (t, 2 H, *J* = 8.7 Hz, *Ar*), 5.27 (m, 1 H, *N-C-H*), 3.86 (s, 3 H, *OMe*), 3.79 (dd, 1 H, *J* = 12.2, 12.2 Hz, *CH_2*), 3.51 (s, 3 H, *OMe*), 3.44 (ddd, 1 H, *J* = 13.8, 9.7, 0.9 Hz, *CH_2*), 2.89 (dd, 1 H, *J* = 13.9, 8.4 Hz), *CH_2*, 2.44 (dd, 1 H, *J* = 12.5, 6.3 Hz, *CH_2*), 1.03-0.93 (m, 21 H, *TIPS*).
^{13}C NMR (101 MHz, $CDCl_3$) δ 170.9, 168.6, 168.3, 162.4 (d, *J* = 247 Hz), 137.7 (d, *J* = 4 Hz), 134.1, 132.0, 130.4 (d, *J* = 8 Hz), 123.2, 113.9 (d, *J* = 21 Hz), 87.1, 70.0, 52.4, 52.3, 47.6, 41.9, 36.1, 18.2, 18.1, 13.7[15]
IR 2951 (w), 2894 (w), 2869 (w), 1775 (w), 1739 (m), 1714 (s), 1514 (w), 1379 (m), 1129 (m)
HRMS (ESI) calcd for $C_{32}H_{41}FNO_7Si$ $[M+H]^+$ 598.2631; found 598.2708.

***Trans*-Dimethyl-4-(1,3-dioxoisoindolin-2-yl)-2-(4-(methoxycarbonyl)phenyl)-2-((triisopropyl-silyl)oxy) cyclopentane-1,1-dicarboxylate (6fe):**



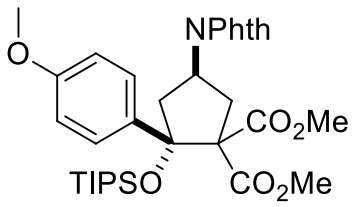
Using the method described above, 181 mg (0.284 mmol, 95%) of a single diastereomer as a colorless solid was obtained.
R_f 0.5 (6:4, Hexane/Ethyl acetate).
Mp 151.5 °C.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.99 (m, 2 H, *Ar*), 7.88-7.82 (m, 4 H, *Ar + Phth*), 7.75 (m, 2 H, *Phth*), 5.28 (m, 1 H, *N-C-H*), 3.92 (s, 3 H, *OMe*), 3.85 (s, 3H, O*Me*), 3.81 (dd, 1 H, *J* = 12.4 Hz, *CH_2*), 3.52-3.42 (m, 4 H, *OMe + CH_2*), 2.88 (dd, 1 H, *J* = 13.9, 8.1 Hz, *CH_2*), 2.47 (dd, 1 H, *J* = 12.4, 6.2 Hz, *CH_2*), 1.03-0.91 (m, 21 H, *TIPS*).
^{13}C NMR (101 MHz, $CDCl_3$) δ 170.7, 168.5, 168.3, 166.9, 146.7, 134.1, 131.9, 129.5, 128.7, 128.3, 123.3, 87.2, 70.0, 52.5, 52.3, 52.1, 47.4, 41.7, 36.1, 18.2, 18.1, 13.7[15]
IR 2953 (w), 2870 (w), 2256 (w), 1712 (m), 1283 (w), 908 (s), 731 (s)
HRMS (ESI) calcd for $C_{34}H_{43}NNaO_9Si^+$ $[M+Na]^+$ 660.2599; found 660.2604

***Trans*-Dimethyl-2-(4-cyanophenyl)-4-(1,3-dioxoisoindolin-2-yl)-2-((triisopropylsilyl)oxy)cyclo-pentane-1,1-dicarboxylate (6ff)**:



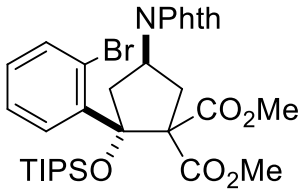
Using the method described above, 127 mg (0.210 mmol, 70%) of a single diastereomer as a colorless solid was obtained.
R_f 0.42 (6:4, Hexane/Ethyl acetate).
Mp 116.5 °C.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93-7.84 (m, 4 H, *Ar + Phth*), 7.76 (m, 2 H, *Phth*), 7.63 (m, 2 H, *Ar*), 5.27 (m, 1 H, *N-C-H*), 3.85 (s, 3 H, O*Me*), 3.77 (dd, 1 H, 12.2, 12.2 Hz, C*H_2*), 3.55 (s, 3 H, O*Me*), 3.50 (dd, 1 H, *J* = 14.1, 10.2 Hz, C*H_2*), 2.86 (dd, 1 H, *J* = 14.1, 7.8 Hz, C*H_2*), 2.46 (dd, 1 H, *J* = 12.5, 6.5 Hz, C*H_2*), 1.04-0.91 (m, 21 H, TIPS).
^{13}C NMR (101 MHz, $CDCl_3$) δ 170.6, 168.3, 168.2, 146.9, 134.2, 131.9, 130.8, 129.5, 123.3, 118.9, 111.8, 86.9, 69.9, 52.6, 52.5, 47.0, 41.5, 36.0, 18.2, 18.1, 13.8[15]
IR 2951 (w), 2869 (w), 2230 (w), 1739 (m), 1712 (s), 1380 (m), 1136 (m), 1124 (m), 983 (m), 912 (m), 735 (s), 727 (s)
HRMS (ESI) calcd for $C_{33}H_{40}N_2NaO_7Si^+$ $[M+Na]^+$ 627.2497; found 627.2499

***Trans*-Dimethyl 4-(1,3-dioxoisoindolin-2-yl)-2-(4-methoxyphenyl)-2-((triisopropylsilyl)oxy)cyclopentane-1,1-dicarboxylate (6fg)**:



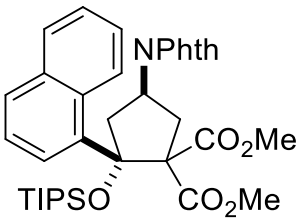
Using the method described above, 182 mg (0.298 mmol, 99%) of a single diastereomer as a colorless solid was obtained.
R_f 0.48 (6:4, Hexane/Ethyl acetate).
Mp 142.3 °C.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (m, 2 H, *Phth*), 7.74 (m, 2 H, *Phth*), 7.69 (d, J = 9.0 Hz, 2 H, *Ar*), 6.83 (d, J = 9.0 Hz, 2 H, *Ar*), 5.27 (m, 1 H, *N-C-H*), 3.86 (s, 3 H, *OMe*), 3.83 (s, 3 H, *OMe*), 3.78 (dd, 1 H, *J* = 12.2, 12.2 Hz, *CH_2*), 3.51 (s, 3 H, *OMe*), 3.42 (ddd, 1 H, J = 13.6, 9.7, 0.7 Hz, *CH_2*), 2.89 (dd, 1 H, *J* = 13.8, 8.6 Hz, *CH_2*), 2.43 (dd, 1 H, *J* = 12.3, 6.2 Hz, *CH_2*), 1.04-0.93 (m, 21 H, *TIPS*)
^{13}C NMR (101 MHz, $CDCl_3$) δ 171.1, 168.8, 168.3, 159.1, 134.0, 133.99, 132.0, 129.7, 123.2, 112.3, 87.4, 70.0, 55.2, 52.3, 52.2, 47.8, 41.9, 36.2, 18.2, 18.2, 13.7[15]
IR 2949 (w), 2868 (w), 1776 (w), 1737 (m), 1712 (s), 1378 (m), 1255 (m), 1125 (m), 981 (m), 722 (s).
HRMS (ESI) calcd for $C_{33}H_{43}NNaO_8Si^+$ $[M+Na]^+$ 632.2650; found 632.2651.

***Trans*-Dimethyl-2-(2-bromophenyl)-4-(1,3-dioxoisoindolin-2-yl)-2-((triisopropylsilyl)oxy)cyclopentane-1,1-dicarboxylate (6fh):**



Using the method described above, 183 mg (0.277 mmol, 92%) of a single diastereomer as a colorless solid was obtained.
The two enantiomers were separated by HPLC using Chiralpack IC column (0.46x25 cm), 95:5 Hexane/Isopropanol, 1 ml/min; tr_1 = 20.9 min; tr_2 = 24.9 min, $[\alpha]_D^{25.0}$ – 43.0 (c = 1, $CHCl_3$)
R_f 0.46 (6:4, Hexane/Ethyl acetate).
Mp 155.7 °C.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88-7.81 (m, 3 H, *Phth +Ar*), 7.71 (m, 2 H, *Phth*), 7.57 (dd, 1 H, *J* = 8.0, 1.4 Hz, *Ar*), 7.24 (m, 1 H, *Ar*), 7.06 (m, 1 H, *Ar*), 5.22 (m, 1 H, *N-C-H*), 4.40 (dd, 1 H, J = 12.8, 12.8 Hz, *CH_2*), 3.79 (s, 3 H, *OMe*), 3.60 (s, 3 H, *OMe*), 3.35 (dd, 1 H, J = 13.5, 10.0 Hz, *CH_2*), 2.78 (dd, 1 H, *J* = 13.7, 7.4 Hz, *CH_2*), 2.60 (dd, 1 H, *J* = 12.9, 6.0 Hz, *CH_2*), 1.04-0.94 (m, 21 H, *TIPS*).
^{13}C NMR (101 MHz, $CDCl_3$) δ 174.4, 172.0, 171.6, 143.1, 137.1, 135.8, 135.2, 133.7, 130.8, 127.3, 124.6, 123.2, 89.0, 70.3, 50.4, 50.4, 45.7, 40.8, 33.5, 14.9, 14.7, 10.3.[15]
IR 2949 (w), 2868 (w), 2259 (w), 2255 (w), 1774 (w), 1758 (m), 1737 (s), 1712 (s), 1378 (m), 913 (m), 734 (s), 722 (s)
HRMS (ESI) calcd for $C_{32}{}^{79}BrH_{41}NO_7Si^+$ $[M+H]^+$ 658.1830; found 658.1835

***Trans*- Dimethyl 4-(1,3-dioxoisoindolin-2-yl)-2-(naphthalen-2-yl)-2-((triisopropylsilyl)oxy)cyclo-pentane-1,1-dicarboxylate (6fi)**:



Using the method described above, 171 mg (0.272 mmol, 91%) of a single diastereomer as a colorless solid were obtained.

R_f 0.6 (6:4, Hexane/Ethyl acetate)

Mp 193.8 °C.

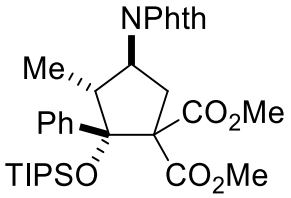
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.39 (d, 1 H, *J* = 8.4 Hz, *Ar*), 7.90-7.79 (m, 5 H, *Phth*+ *Ar*), 7.75 (m, 2 H, *Phth*), 7.45 (t, 1 H, *J* = 7.8 Hz, *Ar*), 7.42-7.33 (m, 2 H, *Ar*), 5.42 (m, 1 H, *N-C-H*), 3.90 (dd, 1 H, *J* = 12.5, 1.5 Hz, *CH_2*), 3.76 (dd, 1 H, *J* = 14.3, 11.7 Hz, *CH_2*), 3.63 (s, 3 H, *OMe*), 3.43 (s, 3 H, *OMe*), 2.95 (dd, 1 H, *J* = 14.4, 4.7 Hz, *CH_2*), 2.67 (dd, 1 H, *J* = 12.5, 7.3 Hz, *CH_2*), 1.08-1.03 (m, 12 H, *TIPS*), 0.73-0.68 (m, 9 H, *TIPS*)

^{13}C NMR (101 MHz, $CDCl_3$) δ 171.0, 169.8, 168.3, 136.4, 134.5, 134.0, 132.4, 132.0, 129.7, 128.8, 128.5, 124.7, 124.0, 123.6, 123.3, 90.9, 68.6, 52.4, 52.2, 45.5, 43.7, 37.8, 18.5, 17.9, 14.3[15]

IR 3050 (w), 2949 (w), 2894 (w), 2868 (w), 2258 (w), 1775 (w), 1762 (w), 1734 (s), 1712 (s), 1378 (m), 1123 (m), 970 (m), 910 (m), 732 (s).

HRMS (ESI) calcd for $C_{36}H_{44}NO_7Si^+$ $[M+H]^+$ 630.2882; found 630.2876.

Dimethyl 4-(1,3-dioxoisoindolin-2-yl)-3-methyl-2-phenyl-2-((triisopropylsilyl)oxy)cyclo-pentane-1,1-dicarboxylate (6fj):



Using the method described above, 164 mg (0.275 mmol, 92%) of two diastereomers (20:1) as a colorless solid was obtained.

The two enantiomers were separated by HPLC using Chiralpack IA column (0.46x25 cm), 93:7 Hexane/Isopropanol, 1 ml/min; tr_1 = 7.5 min, $[\alpha]_D^{25.0}$ 48.4 (c = 1, $CHCl_3$); tr_2 = 12.8 min.

Major diastereomer

R_f 0.52 (6:4, Hexane/Ethyl acetate).

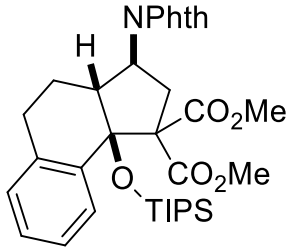
Mp 120 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 (m, 2 H, *Phth*), 7.73 (m, 2 H, *Phth*), 7.69-7.65 (m, 2 H, *Ar*), 7.36-7.27 (m, 3 H, *Ar*), 4.90 (td, 1 H, *J* = 11.1, 6.9 Hz, *N-C-H*), 3.99 (m, 1 H, *CH*CH_3), 3.78 (s, 3 H, *OMe*), 3.53 (s, 3 H, *OMe*), 3.45 (dd, 1 H, *J* = 14.3, 11.0 Hz, *CH_2*), 2.72 (dd, J = 14.3, 6.9 Hz, 1 H, *CH_2*), 1.25-1.07 (m, 15 H, *TIPS* + *Me*), 0.99-0.95 (m, 9 H, *TIPS*).

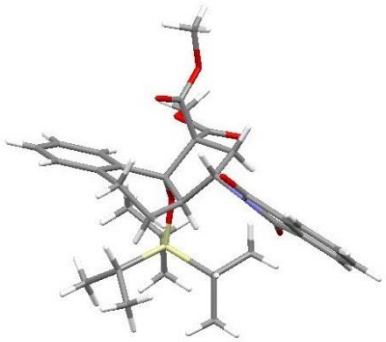
^{13}C NMR (101 MHz, $CDCl_3$) δ 170.8, 168.7, 168.5, 139.6, 134.0, 131.9, 129.6, 127.8, 126.7, 123.2, 90.6, 70.1, 53.1, 52.3, 43.4, 34.1, 18.8, 18.7, 15.1, 11.9[15]

IR 2950 (w), 2869 (w), 1758 (w), 1739 (s), 1739 (s), 1717 (s), 1381 (m), 1126 (m), 735 (m), 724 (s).
HRMS (ESI) calcd for $C_{33}H_{43}NNaO_7Si^+$ $[M+Na]^+$ 616.2701; found 616.2717.

Dimethyl-3-(1,3-dioxoisoindolin-2-yl)-9b-((triisopropylsilyl)oxy)-3,3a,4,5-tetrahydro-1H-cyclopenta[a]naphthalene-1,1(2H,9bH)-dicarboxylate (6fk):

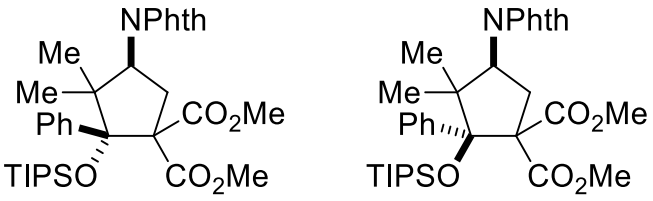


Using the method described above, 166 mg (0.274 mmol, 91%) of two diastereomers (10:1) as a colorless solid were obtained.
The major diastereomer was recrystallized from isopropanol:
R_f 0.50 (6:4, Hexane/Ethyl acetate).
Mp 179.1 °C
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.20 (d, 1 H, J = 7.0 Hz, *Ar*), 7.88 (m, 2 H, *Phth*), 7.76 (m, 2 H, *Phth*), 7.22 (dd, 1 H, J = 7.2, 7.2 Hz, *Ar*), 7.16 (dd, 1 H, *J* = 7.4, 7.0 Hz, *Ar*), 7.07 (d, 1 H, J = 7.6 Hz, *Ar*), 5.17 (m, 1 H, *N-C-H*), 3.98 (dd, 1 H, *J* = 12.9, 12.9 Hz, *CH_2*-C(CO_2Me)$_2$), 3.88 (s, 3 H, O*Me*), 3.32 (m, 1 H, -C*H*-), 3.26 (s, 3 H, O*Me*), 3.04 (m, 1 H, , Ar-C*H_2*), 2.63 (m, 1 H, Ar-C*H_2*), 2.16 (dd, 1 H, *J* = 12.6, 5.6 Hz, *CH_2*-C(CO_2Me)$_2$), 1.87 (m, 1 H, Ar-CH_2-*CH_2*), 1.66 (m, 1 H, Ar-CH_2-*CH_2*), 1.10-0.87 (m, 21 H, *TIPS*)
^{13}C NMR (101 MHz, $CDCl_3$) δ 170.8, 168.5, 168.3, 140.2, 138.2, 134.1, 131.9, 129.2, 127.5, 127.3, 126.1, 123.3, 83.4, 71.0, 52.5, 52.1, 50.3, 49.8, 34.3, 25.3, 21.2, 18.4, 18.0, 14.0[15]
IR 2950 (w), 2868 (w), 2256 (w), 1773 (w), 1715 (s), 1381 (m), 1128 (m), 908 (s), 731 (s)
HRMS (ESI) calcd for $C_{34}H_{43}NNaO_7Si^+$ $[M+Na]^+$ 628.2701; found 628.2722.



The crystal structure has been deposited at the Cambridge Crystallographic Data Centre and allocated the deposition number : CCDC 842233

Dimethyl-4-(1,3-dioxoisoindolin-2-yl)-3,3-dimethyl-2-phenyl-2-((triisopropylsilyl)oxy)cyclopentane-1,1-dicarboxylate (6fl):



Isomer 1 Isomer 2

Using the method described above, 147 mg (0.242 mmol, 81%) of two non-separable diastereomers (4:1) as a colorless solid were obtained.

R_f 0.52 (6:4, Hexane/Ethyl acetate)

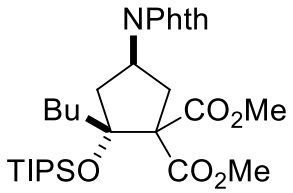
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93 (m, 2 H, *Ar, Isomer 1 & 2*), 7.84 (m, 2.5 H, *Phth, Isomer 1 & 2*), 7.79-7.72 (m, 3 H, *Phth + Ar, Isomer 1 & 2*), 7.51 (m, 0.5 H, *Ar, Isomer 2*), 7.34-7.24 (m, 4 H, *Ar, Isomer 1 & 2*), 5.12 (dd, 1 H, *J* = 13.0, 7.3 Hz, *N-C-H, Isomer 1*), 4.77 (m, 0.25 H, *N-C-H, Isomer 2*), 4.48 (dd, 0.25 H, *J* = 13.4, 13.4 Hz, *CH_2, Isomer 2*), 3.86 (s, 3 H, *OMe, Isomer 1*), 3.78 (s, 0.75 H, *OMe, Isomer 2*), 3.69-3.61 (m, 1.75 H, *OMe, Isomer 2, CH_2, Isomer 1*), 3.55 (s, 3 H, *OMe, Isomer 1*), 3.02 (dd, 1 H, J = 13.4, 7.4 Hz, *CH_2, Isomer 1*), 2.40 (dd, 0.25 H, *J* = 13.3, 7.4 Hz, *CH_2, Isomer 2*), 1.52 (s, 3 H, *Me, Isomer 1*), 1.41 (s, 0.75 H, *Me, Isomer 2*), 1.31 (s, 3 H, *Me, Isomer 1*), 1.04 (s, 0.75 H, *Me, Isomer 2*), 1.02-0.98 (m, 12 H, *TIPS, Isomer 1 & 2*), 0.97-0.92 (m, 10 H, *TIPS, Isomer 1 & 2*), 0.90-0.80 (m, 4 H, *TIPS, Isomer 1 & 2*)

^{13}C NMR (101 MHz, $CDCl_3$) δ 172.2, 170.2, 169.7, 169.3, 141.8, 141.4, 134.1, 134.0, 131.8, 129.5, 128.5, 127.7, 127.4, 127.2, 126.9, 123.2, 93.3, 69.6, 58.8, 57.8, 53.3, 52.9, 52.7, 52.5, 52.4, 32.9, 32.5, 29.0, 25.2, 23.6, 21.4, 19.0, 18.8, 18.8, 15.0, 14.6[15,16]

IR 2949 (w), 2869 (w), 1777 (w), 1735 (m), 1716 (s), 1373 (m), 1034 (m), 911 (m), 731 (s).

HRMS (ESI) calcd for $C_{34}H_{46}NO_7Si^+$ $[M+H]^+$ 608.3038; found 608.3010

***Trans*-dimethyl 2-butyl-4-(1,3-dioxoisoindolin-2-yl)-2-((triisopropylsilyl)oxy)cyclopentane-1,1-dicarboxylate (6fm):**



Using the method described above, 164 mg (0.293 mmol, 98%) of a colorless oil were obtained.

A mixture of 4 diatereo- and regioisomers in the crude NMR with a ratio of 16.6:5:5:1 were identified by 2D NMR.

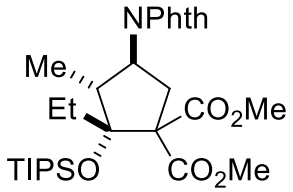
R_f 0.25 (9:1, Hexane/Ethyl acetate)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88-7.80 (m, 3 H), 7.76-7.69 (m, 3 H), 5.34 (q, 0.1 H, *J* = 9.8 Hz), 5.12 (m, 1 H), 4.76 (m, 0.25 H), 4.46 (m, 0.06 H), 3.85-3.82 (m, 3.5 H), 3.80-3.74 (m, 4.6 H), 3.39 (t, 0.05 H, *J* = 12.7 Hz), 3.38-3.26 (m, 1.30 H), 2.95 (dd, 1 H, J = 12.7, 11.3 Hz), 2.75 (m, 0.06 H), 2.64 (dd, 1 H, J = 14.5, 7.0 Hz), 2.57-2.47 (m, 0.9 H), 2.47-2.40 (dd, 0.2 H, *J* = 14.6, 5.7 Hz), 2.10 (dd, 1 H,

[16] not all the signals of the minor diastereoisomer were resolved by ^{13}C.

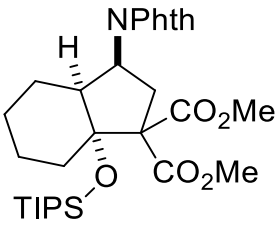
J = 12.8, 7.3 Hz), 1.91 (m, 1 H), 1.57 (m, 0.3 H), 1.53-1.26 (m, 8 H), 1.06-1.21 (m, 30 H), 0.90 (t, 4 H, *J* = 7.3 Hz), 0.75 (t, 0.9 H, *J* = 7.2 Hz), 0.67 (t, 0.3 H, *J* = 7.3 Hz).
^{13}C NMR (101 MHz, $CDCl_3$) δ 171.5, 169.3, 168.3, 133.9, 132.0, 123.2, 123.1, 88.6, 68.9, 52.5, 52.4, 50.8, 47.4, 41.2, 36.6, 35.1, 34.6, 29.6, 28.1, 23.4, 22.3, 21.3, 18.6, 18.5, 18.4, 18.3, 14.4, 14.1, 13.9, 13.8[15]
IR 2952 (w), 2895 (w), 2868 (w), 1776 (w), 1741 (s), 1714 (s), 1377 (m), 1129 (m).
HRMS (ESI) calcd for $C_{29}H_{44}NO_7Si^+$ $[M+H]^+$ 560.3038; found 560.3030

Dimethyl-4-(1,3-dioxoisoindolin-2-yl)-2-ethyl-3-methyl-2-((triisopropylsilyl)oxy)cyclopentane-1,1-dicarboxylate (3fn):



Using the method described above, 157 mg (0.288 mmol, 96%) of a colorless oil were obtained.
Starting from a 1:8 mixture of *Z*:*E* silyl enol ether, a mixture of 3 diastereomer with a ratio of 11:4:1 was identified by 2D NMR.
R_f 0.7 (6:4, Hexane/Ethyl acetate)
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.88-7.81 (m, 2 H), 7.69-7.76 (m, 3 H), 4.86 -4.73 (m, 1 H), 4.55-4.43 (m, 0 H), 3.81-3.69 (m, 8 H), 3.54-3.40 (m, 1 H), 3.39-3.31 (m, 1 H), 3.08 (dd, 1 H, J = 14.3, 10.6 Hz), 2.72-2.58 (m, 2 H), 2.36-2.20 (m, 1 H), 1.99-1.88 (m, 1 H), 1.88-1.80 (m, 0 H), 1.23 (t, 1 H, J = 7.0 Hz), 1.20-1.09 (m, 29 H), 1.09-0.96 (m, 9 H)
^{13}C NMR (101 MHz, $CDCl_3$) δ 171.6, 171.3, 169.6, 169.5, 168.6, 168.3, 133.9, 132.0, 131.8, 123.2, 123.1, 89.9, 87.8, 67.6, 67.2, 54.0, 52.6, 52.4, 52.4, 52.3, 48.5, 42.6, 35.1, 34.8, 30.5, 29.7, 29.4, 18.7, 18.6, 18.5, 18.4, 18.0, 14.6, 14.1, 13.4, 13.3, 11.3, 9.9, 9.7[15]
IR 2951 (w), 2869 (w), 1737 (m), 1715 (s), 1378 (m), 1266 (w), 1249 (w), 1127 (m)
HRMS (ESI) calcd for $C_{29}H_{44}NO_7Si$+ $[M+H]^+$ 546.2882; found 546.2870

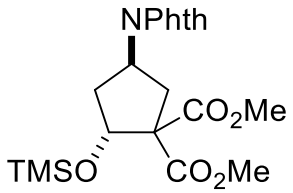
Dimethyl-3-(1,3-dioxoisoindolin-2-yl)-7a-((triisopropylsilyl)oxy)octahydro-1H-indene-1,1-dicarboxylate (6fo):



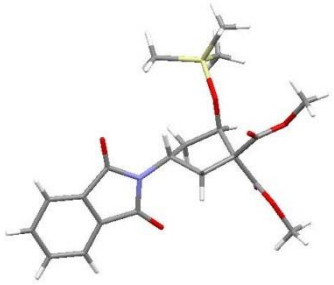
Using the method described above, 159 mg (0.285 mmol, 95%) of three diastereomers (14:3:1) as a colorless oil were obtained. The major diastereomer was separated from others by column chromatography.
The two enantiomers were separated by HPLC using Chiralpack IB column (0.46x25 cm), 98:2 Hexane/Isopropanol, 0.6 ml/min; tr_1 = 20.0 min, $[\alpha]_D^{25.0}$ 20.1 (c = 0.5, $CHCl_3$); tr_2 = 24.4 min, **R_f** 0.70 (6:4, Hexane/Ethyl acetate).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (m, 2 H, *Phth*), 7.71 (m, 2 H, *Phth*), 5.25 (ddd, 1 H, *J* = 10.1, 10.1, 7.1 Hz, *N-C-H*), 4.04 (dd, 1 H, *J* = 14.4, 10.5 Hz, *CH_2 cyclopentane*), 3.78 (s, 3 H, *OMe*), 3.74 (s, 3 H, *OMe*), 3.03 (dd, 1 H, *J* = 14.4, 9.8 Hz, *CH_2 cyclopentane*), 2.91 (m, 1 H, *CH_2*), 2.38 (m, 1 H, -*CH*-), 1.80-1.54 (m, 4 H, *CH_2*), 1.54-1.41 (m, 1 H, *CH_2*), 1.39-1.28 (m, 1H, *CH_2*), 1.23-1.09 (m, 22 H, *TIPS* + *CH_2*)
^{13}C NMR (101 MHz, $CDCl_3$) δ 170.2, 169.3, 169.2, 133.9, 131.9, 123.1, 87.1, 68.0, 52.8, 52.8, 52.6, 52.5, 34.4, 29.9, 23.9, 23.3, 23.2, 18.4, 18.6, 13.7[15]
IR 2949 (w), 2867 (w), 1774 (w), 1739 (m), 1715 (s), 1373 (w), 1133 (w)
HRMS (ESI) calcd for $C_{30}H_{44}NO_7Si$+ [M+H]+ 558.2882; found 558.2892.

***Trans*-Dimethyl-4-(1,3-dioxoisoindolin-2-yl)-2-((trimethylsilyl)oxy)cyclopentane-1,1-dicarboxylate (6fp):**

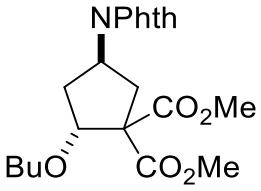


Using the method described above, 97.0 mg (0.231 mmol, 77%) of a single diastereomer as a colorless solid was obtained.
The two enantiomers were separated by HPLC using Chiralpack IA column (0.46x25 cm), 98:2 Hexane/Isopropanol, 1 ml/min; tr_1 = 19.8 min; tr_2 = 24.0 min, $[\alpha]_D^{25.0}$ - 51 (c = 0.68, $CHCl_3$)
R_f 0.40 (6:4, Hexane/Ethyl acetate).
Mp 120.6 °C.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80 (m, 2 H, *Phth*), 7.69 (m, 2 H, *Phth*), 5.11 (m, 1 H, *N-C-H*), 4.99 (dd, 1 H, *J* = 4.1, 1.8 Hz, *O-C-H*), 3.82 (s, 3 H, *OMe*), 3.72 (s, 3 H, *OMe*), 3.14 (dd, 1 H, *J* = 14.4, 10.7 Hz, *CH_2*), 2.55 (m, 1 H, *CH_2*), 2.46 (dd, 1 H, *J* = 14.5, 6.6 Hz, *CH_2*), 1.98 (ddd, 1 H, *J* = 12.9, 7.9, 1.9 Hz, *CH_2*), 0.11 (m, 9 H, *TMS*).
^{13}C NMR (101 MHz, $CDCl_3$) δ 171.3, 169.0, 168.0, 134.0, 131.9, 123.2, 76.4, 66.0, 52.8, 52.5, 47.6, 38.7, 33.8, 0.0.
IR 2955 (w), 1775 (w), 1737 (s), 1710 (s), 1378 (m), 1251 (m), 1124 (m), 844 (s), 720 (s).
HRMS (ESI) calcd for $C_{20}H_{26}NO_7Si^+$ $[M+H]^+$ 420.1473; found 420.1483.



The crystal structure has been deposited at the Cambridge Crystallographic Data Centre and allocated the deposition number : CCDC 842234

***Trans*-dimethyl 2-butoxy-4-(1,3-dioxoisoindolin-2-yl)cyclopentane-1,1-dicarboxylate (6fq):**



Using the method described above, 119 mg (0.296 mmol, 99%) of two unseparable diastereomers (20:1) as colorless oil were obtained.

Major diastereomer:

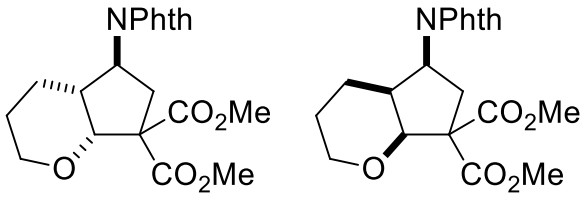
R_f 0.5 (6:4 Hexane/Ethyl acetate)

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 (m, 2 H, *Phth*), 7.72 (m, 2 H, *phth*), 5.06 (m, 1 H, *N-C-H*), 4.64 (dd, 1 H, *J* = 4.2, 2.1 Hz, -C*H*-O), 3.87 (s, 3 H, *OMe*), 3.77 (s, 3 H, *OMe*), 3.57 (dt, 1 H, *J* = 9.2, 6.1 Hz, OCH_2 *n*-butyl), 3.38 (dt, 1 H, *J* = 9.2, 6.5 Hz, OCH_2 *n*-butyl), 3.14 (dd, 1 H, *J* = 14.5, 10.7 Hz, CH_2-C$(CO_2Me)_2$), 2.54-2.42 (m, 2 H, CH_2-CH-O-), 2.23 (ddd, 1 H, *J* = 13.2, 8.1, 2.1 Hz, CH_2-C$(CO_2Me)_2$), 1.59-1.45 (m, 2 H, CH_2 *n*-butyl), 1.42-1.25 (m, 2 H, CH_2 *n*-butyl), 0.92 (t, 4 H, *J* = 7.4 Hz, CH_3).

^{13}C NMR (101 MHz, $CDCl_3$) δ 171.3, 169.0, 168.0, 134.0, 131.9, 123.2, 83.1, 69.6, 64.9, 52.9, 52.6, 47.4, 34.8, 34.1, 31.8, 19.3, 13.9

HRMS (ESI) calcd for $C_{21}H_{26}NO_7^+$ $[M+H]^+$ 404.1704; found 404.1720.

Dimethyl 5-(1,3-dioxoisoindolin-2-yl)hexahydrocyclopenta[b]pyran-7,7(7aH)dicarboxylate (6fr):



6fr-trans **6fr-cis**

Using the method described above, 115 mg (0.297 mmol, 99%) of two diastereomers (1.7:1) as a colorless solid was obtained. The two isomers were separated by column chromatography.

6fr-trans

Recrystallized in isopropanol

R_f 0.13 (6:4, Hexane/Ethyl acetate).

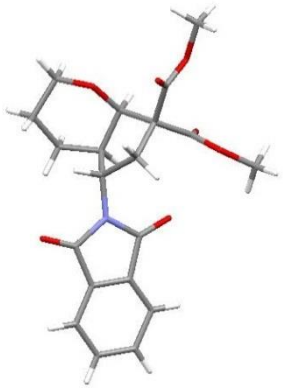
Mp 169.2 °C.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 (m, 2 H, *Phth*), 7.72 (m, 2 H, *Phth*), 4.87 (m, 1 H, *N-C-H*), 4.29 (d, 1 H, *J* = 11.8 Hz, *O-C-H*), 4.05 (dd, 1 H, *J* = 11.5, 4.5 Hz, *CH*$_2$*-O*), 3.89 (s, 3 H, *OMe*), 3.79 (s, 3 H, *OMe*), 3.51 (dd, 1 H, *J* = 12.1, 12.1, 3.0 Hz, *CH*$_2$*-O*), 3.04 (dd, 1 H, *J* = 15.2, 9.6 Hz, *CH*$_2$ *cyclopentane*), 2.70 (dd, 1 H, *J* = 15.2, 2.7 Hz, *CH*$_2$ *cyclopentane*), 2.25 (m, 1 H, *CH cyclopentane*), 1.87 (m, 1 H, *CH*$_2$ *pyran*), 1.68-1.49 (m, 2 H, *CH*$_2$ *pyran*), 1.14 (qd, 1 H, *J* = 12.2, 4.3 Hz, *CH*$_2$ *pyran*).

^{13}C NMR (101 MHz, $CDCl_3$) δ 171.8, 171.0, 168.8, 134.2, 131.5, 123.4, 84.2, 69.2, 61.8, 53.1, 53.0, 49.2, 45.0, 35.0, 25.2, 25.0

IR 2951 (w), 2853 (w), 2255 (w), 1779 (w), 1749 (w), 1731 (m), 1708 (m), 1370 (m), 1276 (m), 723 (s), 648 (s), 634 (s).

HRMS (ESI) calcd for $C_{20}H_{22}NO_7^+$ $[M+H]^+$ 388.1391; found 388.1404.



6fr trans

The crystal structure has been deposited at the Cambridge Crystallographic Data Centre and allocated the deposition number : CCDC 842235

6fr-cis

R_f 0.31 (6:4, Hexane/Ethyl acetate).

Mp 173.5 °C.

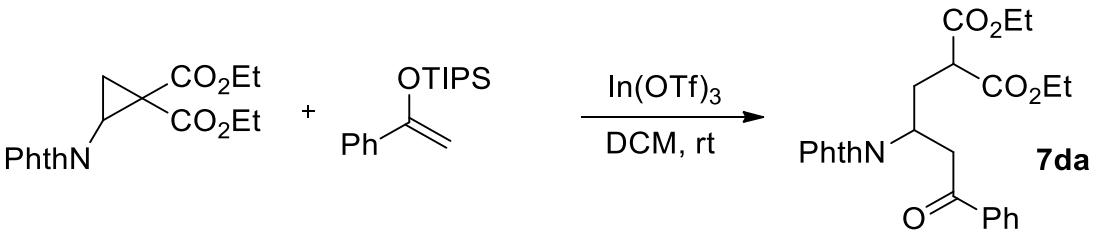
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (m, 2 H, *Phth*), 7.72 (m, 2 H, *Phth*), 5.05 (ddd, 1 H, *J* = 10.9, 10.9, 6.6 Hz, *N-C-H*), 4.47 (d, 1 H, *J* = 3.0 Hz, *O-C-H*), 4.00 (dd, 1 H, J = 11.4, 4.4 Hz, *CH_2-O*), 3.88 (s, 3 H, *OMe*), 3.77 (s, 3 H, *OMe*), 3.40 (dd, 1 H, J = 12.2, 2.1 Hz, *CH_2*-O), 3.27 (dd, 1 H, *J* = 14.6, 11.0 Hz, *CH_2 cyclopentane*), 2.87 (m, 1 H, *CH cyclopentane*), 2.64 (dd, 1 H, *J* = 14.6, 6.5 Hz, *CH_2 cyclopentane*), 1.99 (m, 1 H, *CH_2 pyran*), 1.74 (m, 1 H, *CH_2 pyran*), 1.59 (m, 1 H, *CH_2 pyran*), 1.40 (m, 1 H, *CH_2 pyran*).

^{13}C NMR (101 MHz, $CDCl_3$) δ 171.0, 168.8, 168.2, 134.0, 131.9, 123.2, 82.1, 67.9, 63.9, 52.9, 52.9, 49.0, 40.9, 33.0, 21.0, 20.0.

IR 2954 (w), 2858 (w), 1736 (s), 1710 (s), 1383 (m), 1108 (m), 912 (m), 719 (s)

HRMS (ESI) calcd for $C_{20}H_{22}NO_7^+$ $[M+H]^+$ 388.1391; found 388.1395.

Diethyl 2-(2-(1,3-dioxoisoindolin-2-yl)-4-oxo-4-phenylbutyl)malonate (7da):

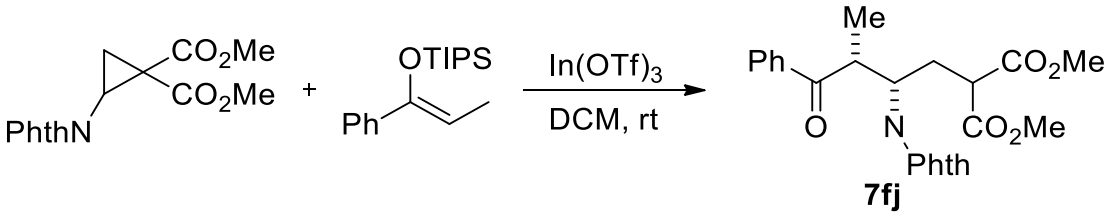


Indium (III) trifluoromethanesulfonate (17.0 mg, 0.026 mmol, 20 mol %) is weighted in the glovebox. The flask is closed with a septum and put under N_2 atmosphere. A solution of aminocyclopropane (50 mg, 0.15 mmol, 1 eq) and silyl enol ether (50 mg, 0.18 mmol, 1.2 eq) in 1 mL of dry dichloromethane is added. The reaction is stirred overnight at room temperature. The reaction is filtered through a plug of silica in order to remove the catalyst and concentrated under reduced pressure. Purification by column chromatograpy (6:4 Hexane/Ethyl Acetate) furnished 58 mg (0.13 mmol, 85 % yield) of the desired product as a colorless oil.

R_f 0.32 (6:4 Hexane/Ethyl Acetate).

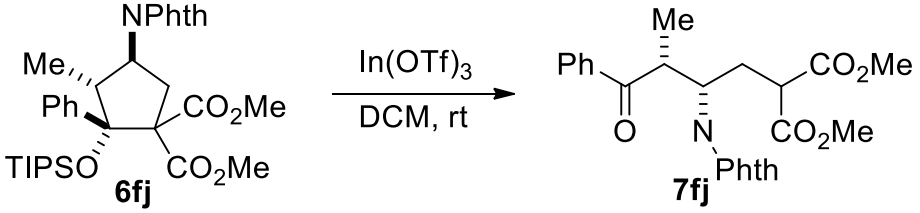
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93 (m, 2 H, *Ar*), 7.87-7.80 (m, 2 H, *Phth*), 7.75-7.68 (m, 2 H, *Phth*), 7.59-7.53 (m, 1 H, *Ar*), 7.48-7.41 (m, 2 H, *Ar*), 5.02-4.94 (m, 1 H, *N-C-H*), 4.29-4.20 (m, 2 H, $CO_2CH_2CH_3$), 4.09-3.92 (m, 3 H, $CO_2CH_2CH_3$ + $CH(CO_2Et)_2$), 3.51 (dd, 1 H, *J* = 17.7, 5.3 Hz, CH_2-CO-Ph), 3.40 (dd, 1 H, *J* = 8.3, 6.2 Hz, CH_2-CO-Ph), 2.79 (ddd, 1 H, *J* = 14.3, 11.0, 6.2 Hz, CH_2), 2.47 (ddd, 1 H, *J* = 14.3, 8.3, 4.1 Hz, CH_2), 1.29 (t, 3 H, *J* = 7.1 Hz, $CO_2CH_2CH_3$), 1.17 (t, 3 H, *J* = 7.1 Hz, $CO_2CH_2CH_3$).
^{13}C NMR (101 MHz, $CDCl_3$) δ 196.7, 168.7, 168.4, 168.2, 136.5, 134.0, 133.4, 131.8, 128.7, 128.1, 123.3, 61.8, 61.6, 49.6, 45.6, 40.7, 31.6, 14.0, 13.9.
IR 2983 (w), 1776 (w), 1748 (m), 1731 (s), 1711 (s), 1687 (w), 1393 (w), 1373 (m).
HRMS (ESI) calcd for $C_{25}H_{26}NO_7^+$ $[M+H]^+$ 452.1704; found 452.1708

dimethyl 2-(2-(1,3-dioxoisoindolin-2-yl)-3-methyl-4-oxo-4-phenylbutyl)malonate (7fj) :



7fj

Following the same procedure described above, using 50 mg (0.17 mmol, 1 eq) of aminocyclopropane, 72 mg (0.25 mmol, 1.5 eq) of silyl enol ether and 18.5 mg (0.033 mmol, 20 mol %) of Indium (III) trifluoromethanesulfonate, 49 mg (0.11 mmol, 67 % yield) of a colorless oil is obtained after column chromatography purification (9:1 Hexane/Ethyl Acetate to 8:2 Hexane/Ethyl Acetate).
4:1 Mixture of syn/anti diastereomers:
R_f 0.29 (6:4 Hexane/Ethyl Acetate).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00-8.04 (m, 2 H, *Ar*), 7.94-7.88 (m, 2 H, *Phth*), 7.88-7.85 (m, 0.5 H, *Phth*), 7.81-7.76 (m, 2 H, *Phth*), 7.76-7.72 (m, 0.5 H, *Phth*), 7.68-7.60 (m, 1.5 H, *Ar*), 7.57-7.46 (m, 2.25 H, *Ar*), 7.42-7.35 (m, 0.5 H, *Ar*), 4.83 (dd, 1 H, *J* = 10.7, 3.2 Hz, *N-C-H*), 4.62 (m, 0.5 H, *N-C-H* + Me-C*H*-CO-Ph), 4.48 (qd, 1 H, *J* = 10.4, 7.0 Hz, Me-C*H*-CO-Ph), 3.79 (s, 0.75 H, CO_2CH_3), 3.76 (s, 3 H, CO_2CH_3), 3.56 (s, 0.75 H, CO_2CH_3), 3.46 (s, 3 H, CO_2CH_3), 3.41-3.33 (m, 1.25 H, $CH(CO_2Et)_2$), 2.76 (ddd, 1 H, *J* = 14.4, 11.4, 6.7 Hz, CH_2), 2.72-2.59 (m, 0.5 H, CH_2), 2.23 (ddd, 1 H, *J* = 14.4, 7.9, 3.2 Hz, CH_2), 1.38 (d, 0.75 H, *J* = 6.8 Hz, CH_3), 1.09 (d, 3 H, *J* = 7.1 Hz, CH_3).
^{13}C NMR (101 MHz, $CDCl_3$) δ 201.8, 201.2, 169.2, 169.1, 168.8, 168.6, 168.5, 136.1, 135.9, 134.3, 134.0, 133.6, 133.2, 131.5, 131.4, 128.9, 128.7, 128.6, 128.4, 123.5, 123.3, 53.0, 52.9, 52.7, 52.5, 51.9, 51.4, 49.8, 48.9, 42.6, 42.3, 30.0, 28.9, 16.5, 16.0
IR 2955 (w), 1753 (m), 1753 (m), 1736 (s), 1710 (s), 1680 (m), 1389 (m), 1367 (m), 723 (s).
HRMS (ESI) calcd for C24H24NO7+ [M+H]+ 438.1547; found 438.1556

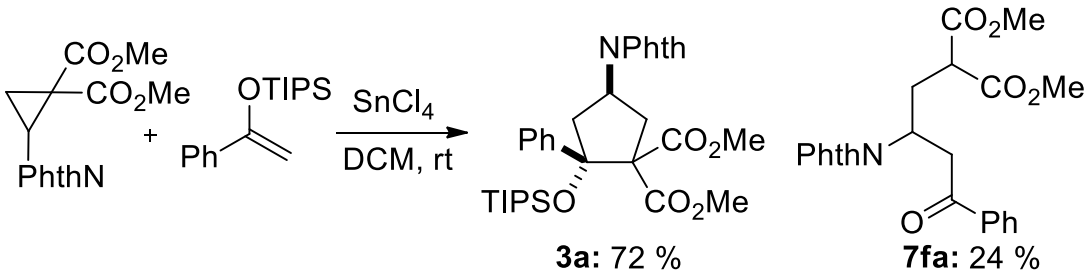


6fj **7fj**

Indium (III) trifluoromethanesulfonate (5 mg, 0.009 mmol, 20 mol %) is weighted in the glovebox. The flask is closed with a septum and put under N_2 atmosphere. A solution of **6fj** (26 mg, 0.044 mmol,

1 eq) in 0.5 mL of dry dichloromethane is added. The reaction is stirred overnight at room temperature. The reaction is filtered through a plug of silica in order to remove the catalyst and concentrated under reduced pressure. Purification by column chromatograpy (6:4 Hexane/Ethyl Acetate) furnished 15 mg (0.043 mmol, 78 % yield) of the desired product as a colorless oil.
dr >20:1 syn/anti
R_f 0.29 (6:4 Hexane/Ethyl Acetate).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 (d, 2 H, *J* = 7.4 Hz, *Ar*), 7.91 (m, 2 H, *Phth*), 7.79 (m, 2 H, *Phth*), 7.64 (m, 1 H, *Ar*), 7.54 (t, 2 H, *J* = 7.8 Hz, *Ar*), 4.84 (ddd, 1 H, *J* = 10.9, 10.9, 3.1 Hz, *N-C-H*), 4.48 (m, 1 H, Me-C*H*-CO-Ph), 3.76 (s, 3 H, CO_2CH_3), 3.47 (s, 3 H, CO_2CH_3), 3.39 (dd, 1 H, *J* = 7.2, 7.2 Hz, C*H*$(CO_2Et)_2$), 2.77 (ddd, 1 H, *J* = 14.4, 11.4, 6.8 Hz, CH_2), 2.24 (ddd, 1 H, *J* = 14.4, 7.9, 3.2 Hz, CH_2), 1.10 (d, 3 H, *J* = 7.1 Hz, , CH_3)
^{13}C NMR (101 MHz, $CDCl_3$) δ 201.2, 169.1, 168.6, 168.4, 136.1, 134.3, 133.6, 131.5, 128.9, 128.6, 123.5, 52.8, 52.5, 51.9, 49.8, 42.3, 30.0, 16.0
IR 2955 (w), 1754 (m), 1736 (s), 1712 (s), 1388 (m), 1368 (m), 723 (s)
HRMS (ESI) calcd for $C_{24}H_{24}NO_7^+$ $[M+H]^+$ 438.1547; found 438.1505.

Dimethyl 2-(2-(1,3-dioxoisoindolin-2-yl)-4-oxo-4-phenylbutyl)malonate (7fa) :



To a solution of aminocyclopropane (50 mg, 0.17 mmol, 1 eq) and silyl enol ether (68 mg, 0,25 mmol, 1.5 eq) in 1 mL of dry dichloromethane under nitrogen, is added 19.2 µl (0.00826 mmol, 5 mol %) of a tin tetrachloride solution (0.43 M) at room temperature. The reaction is stirred one hour at room temperature after what 0.1 mL of triethylamine is added. The solution is concentrated under reduced pressure and purified by column chromatography (9:1 to 8:2 Hexane/Ethyl Acetate). 69 mg (0.12 mmol, 72 %) of **3a** and 16.4 (0.04 mmol, 24 %) of **7fa** are isolated.

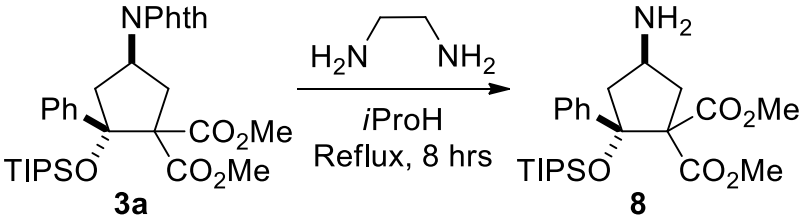
7fa
The two enantiomers were separated by HPLC using Chiralpack IA column (0.46x25 cm), 75:25 Hexane/Isopropanol, 1 ml/min;,

- 72.8 % ee tr_1 = 26.5 min $[\alpha]_D^{25.0}$ - 27.3 (c = 1, $CHCl_3$); tr_2 = 28.2 min.
+ 98 % ee tr_1 = 26.5 min; tr_2 = 28.2 min. $[\alpha]_D^{25.0}$ + 41 (c = 0.6, $CHCl_3$);

Sticky oil,
R_f 0.45 (6:4 Hexane/Ethyl Acetate).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.96-7.90 (m, 2 H, *Ar*), 7.87-7.81 (m, 2 H, *Phth*), 7.76-7.70 (m, 2 H, *Phth*), 7.59-7.54 (m, 1 H, *Ar*), 7.49-7.43 (m, 2 H, *Ar*), 5.02-4.92 (m, 1 H, *N-C-H*), 4.02 (dd, 1 H, *J* = 17.9, 8.7 Hz, C*H*$(CO_2Et)_2$), 3.80 (s, 3 H, CO_2CH_3), 3.57 (s, 3 H, CO_2CH_3), 3.51 (dd, 1 H, *J* = 17.8, 5.3 Hz, CH_2-CO-Ph), 3.45 (dd, 1 H, *J* = 8.5, 6.1 Hz, CH_2-CO-Ph), 2.80 (ddd, 1 H, *J* = 14.3, 11.2, 6.1 Hz, CH_2), 2.48 (ddd, 1 H, *J* = 14.3, 8.6, 3.9 Hz, CH_2).

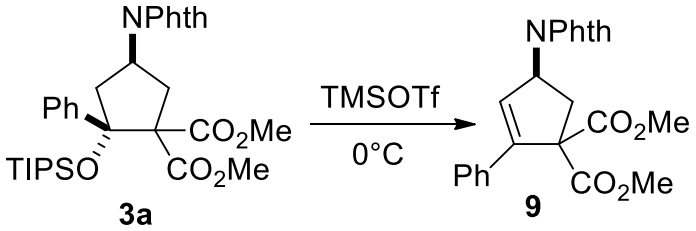
^{13}C NMR (101 MHz, $CDCl_3$) δ 196.7, 169.1, 168.8, 168.2, 136.4, 134.1, 133.5, 131.7, 128.7, 128.1, 123.4, 52.9, 52.7, 49.2, 45.5, 40.7, 31.7.
IR 2956 (w), 1774 (w), 1753 (m), 1734 (s), 1709 (s), 1687 (w), 1373 (m), 1372 (m), 724 (m).
HRMS (ESI) calcd for C23H22NO7+ [M+H]+ 424.1391; found 424.1386

***Trans*-dimethyl 4-amino-2-phenyl-2-((triisopropylsilyl)oxy)cyclopentane-1,1-dicarboxylate (8) :**



Following a modified procedure[17], 100 mg of **3a** (0.172 mmol, 1 eq) is added in an oven dried flask with 52 mg (0.86 mmol, 5 eq) of ethylenediamine. Isopropanol is added and the white suspension is refluxed. After a few minutes, the starting material is completely solubilized and the reaction is heated during 8 h. The solvent is then removed under reduced pressure and the crude oil is purified by column chromatography (9:1 Ethyl Acetate/Hexane + 1% NEt_3). 55 mg (0.12 mmol, 72 %) of a colorless oil corresponding to the free cyclopentylamine is isolated.
R_f 0.2 (100 % Ethyl Acetate)
Mp 200 °C decomposition
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.78-7.74 (m, 2 H, *Ar*), 7.32-7.24 (m, 3 H, *Ar*), 3.82-3.82 (m, 1 H, *N-C-H*), 3.77 (s, 3 H, CO_2CH_3), 3.31 (s, 3 H, CO_2CH_3), 3.17 (dd, 1 H, *J* = 13.9, 8.7 H, CH_2), 2.73 (dd, 1 H, *J* = 13.5, 9.3 Hz, CH_2), 2.61 (dd, 1 H, *J* = 13.4, 6.9 Hz, CH_2), 1.99 (dd, 1 H, J = 14.0, 6.2 Hz, CH_2), 1.76 (br s, 2 H, NH_2), 0.98-0.91 (m, 21 H, *TIPS*).
^{13}C NMR (101 MHz, $CDCl_3$) δ 172.1, 169.2, 142.0, 128.0, 127.8, 127.2, 89.0, 71.3, 52.1, 49.4, 49.0, 44.6, 29.7, 18.2, 13.8
IR 2949 (w), 2949 (w), 2949 (w), 2949 (w), 2868 (w), 1752 (s), 1736 (s), 1717 (s), 1448 (w), 1263 (m), 1106 (s), 1077 (s)
HRMS (ESI) calcd for $C_{24}H_{40}NO_5Si^+$ $[M+H]^+$ 450.2670; found 450.2660

Dimethyl 4-(1,3-dioxoisoindolin-2-yl)-2-phenylcyclopent-2-ene-1,1-dicarboxylate (9) :

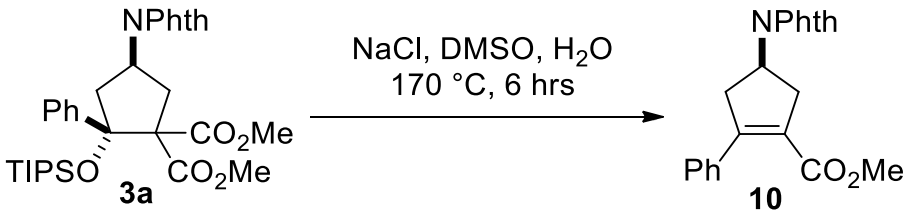


3a (80 mg, 0.14 mmol, 1 eq) is added in an oven dried flask, under nitrogen. 1 mL of dry dichloromethane is added and the solution is cooled to 0 °C with an ice/water bath. TMSOTf (28 µl, 0.15 mmol, 1.1 eq) is added and the reaction is stirred for 10 minutes at 0 °C. The solvent is evaporated under reduced pressure and the crude is purified by column chromatography (8:2 Hexane/Ethyl Acetate). 30 mg of a colorless solid (0.074 mmol, 53 % yield) is isolated.

[17] O. Kanie, S. C. Crawley, M. M. Palcic, O. Hindsgaul, *Carbohydrate Research* **1993**, *243*, 139

R_f 0.43 (6:4 Hexane/Ethyl Acetate).
Mp 132 °C.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90-7.83 (m, 2 H, *Phth*), 7.79-7.72 (m, 2 H, *Phth*), 7.51-7.46 (m, 2 H, *Ar*), 7.37-7.29 (m, 3 H, *Ar*), 6.25 (d, 1 H, *J* = 2.3 Hz, C=C*H*), 5.65-5.58 (m, 1 H, *N-C-H*), 3.82 (s, 3 H, CO_2CH_3), 3.72 (s, 3 H, CO_2CH_3), 3.15 (m, 2 H, CH_2).
^{13}C NMR (101 MHz, $CDCl_3$) δ 171.6, 170.5, 167.9, 143.9, 134.6, 134.1, 131.9, 131.3, 128.0, 128.0, 127.7, 123.4, 53.5, 53.1, 52.8, 40.3, 29.7.
IR 1773 (w), 1732 (m), 1715 (s), 1391 (w), 1368 (w), 1273 (w), 1124 (w), 720 (m).
HRMS (ESI) calcd for $C_{23}H_{20}NO_6^+$ $[M+H]^+$ 406.1285; found 406.1295

<u>Methyl 4-(1,3-dioxoisoindolin-2-yl)-2-phenylcyclopent-1-enecarboxylate (10) :</u>



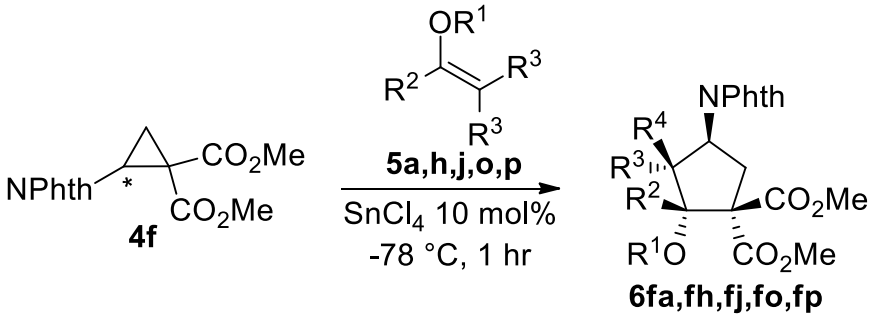
Following a modified procedure[18], **3a** (90 mg, 0.15 mmol, 1 eq) is dissolved is 2 mL dimethylsulfoxide and 5 µl (0.3 mmol, 2 eq) of water. The solution is stirred for 6 h at 170 °C. After cooling to room temperature, the reaction mixture is extracted three times with 5 mL of diethyl ether, washed three times with 5 mL of water, three times with 5mL brine dried over magnesium sulfate and filtered through a cotton plug. The solvents are evaporated under reduced pressure and the crude is purified by column chromatography (8:2 Hexane/Ethyl Acetate). 47 mg (0.14 mmol, 88 % yield) of a white solid is isolated
R_f 0.51 (6:4 Hexane/Ethyl Acetate).
Mp 165 °C.
^{1}H NMR[19] (400 MHz, $CDCl_3$) δ 7.88 (m, 2 H, *Phth*), 7.75 (m, 2 H, *Phth*), 7.31-7.44 (m, 5 H, *Ar*), 5.14 (m, 1 H, *N-C-H*), 3.66 (s, 3 H, CO_2CH_3), 3.50 (m, 1 H, CH_2), 3.35 (m, 1 H, CH_2), 3.19 (m, 2 H, CH_2)
^{13}C NMR[19] (101 MHz, $CDCl_3$) δ 171.5, 168.6, 154.4, 138.0, 135.9, 133.7, 129.8, 129.4, 129.3, 128.1, 124.6, 49.3, 44.5, 41.3, 36.5
IR 2949 (w), 1773 (w), 1710 (s), 1393 (m), 1378 (m), 1236 (m), 722 (m).
HRMS (ESI) calcd for $C_{21}H_{17}NNaO_4^+$ $[M+Na]^+$ 370.1050; found 370.1063

[18] A. P. Krapcho, J. F. Weimaster, J. M. Eldridge, E. G. E. Jahngen Jr., A. J. Lovey, W. P. Stephens, *J. Org. Chem.*, **1978**, *43*, 138
[19] Peaks are splitting due to conformers of methyl ester.

Enantiospecific Reactions

General procedure for enantiospecific cycloaddition :

In an oven-dried flask sealed with a septum and under N_2 atmosphere is added the chiral N-phthalimide aminocyclopropane (16 mg – 26 mg, 0.053 – 0.062 mmol, 1 eq) and the silyl-enol ether (1.5 eq) in dry dichloromethane (0.15 M). The solution is cooled down to -78 °C and a 0.43 M solution of tin tetrachloride (10 mol %) in dry dichloromethane is added. The reaction is stirred for 1 h at -78 °C. Triethylamine (0.1 mL) is then added in one portion at -78 °C. The reaction is warmed at room temperature and stirred for 15 min. Dichloromethane is removed under reduced pressure and the crude is directly purified by column chromatography (8:2 Hexane/Ethyl Acetate).

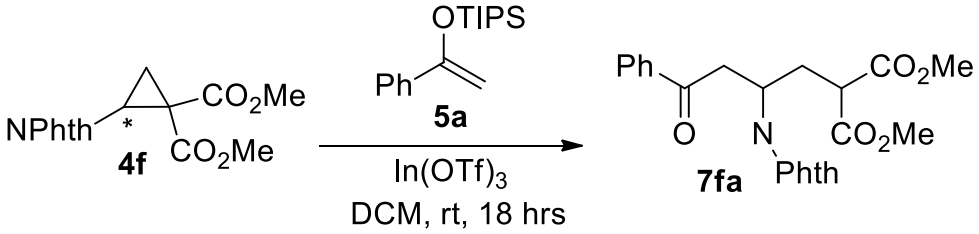


Entry	%ee **4f**	**5**	**6**	Yield %[a]	*dr*[a]	%ee **6**
5	+ 97.4	**5a**	**6fa**	82	> 20:1	98
1	+ 98.6	**5h**	**6fh**	73	> 20:1	81
2	- 94.8	**5j**	**6fj**	76	3:1	94
3	+ 98.9	**5o**	**6fo**	77.5	3:1:1	99.2:99.1:98.9
4	- 97.6	**5p**	**6fp**	74	> 20:1	95.7

[a] Due to the small scale for these experiments, product of retroaldol was detected, affecting the yield and *dr*.

Indium catalysed synthesis of enantioenriched Dimethyl 2-(2-(1,3-dioxoisoindolin-2-yl)-4-oxo-4-phenylbutyl)malonate (7fa):

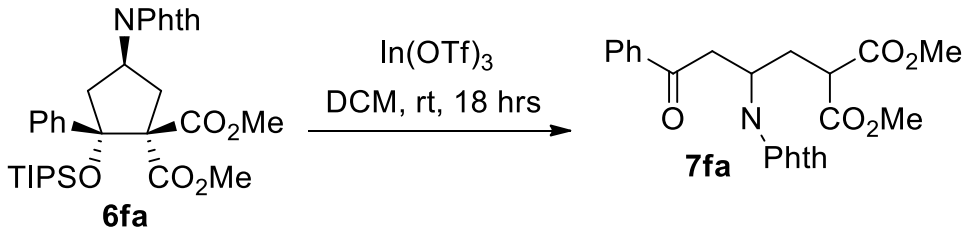
Indium (III) trifluoromethanesulfonate (3.3 mg, 0.018 mmol, 20 mol %) is weighted in the glovebox. The flask is closed with a septum and put under N_2 atmosphere. A solution of aminocyclopropane (18 mg, 0.059 mmol, 1 eq) and silyl enol ether (20 mg, 0.071 mmol, 1.2 eq) in dry dichloromethane (0.15 M) is added. The reaction is stirred overnight at room temperature. The reaction is filtered through a plug of silica in order to remove the catalyst and concentrated under reduced pressure. Purification by column chromatograpy (6:4 Hexane/Ethyl Acetate) furnished 24 mg (0.058 mmol, 94 % yield) of the desired product as a colorless oil.



%ee **4f**	Yield %[a]	%ee **7fa**
- 94	94	- 72.8

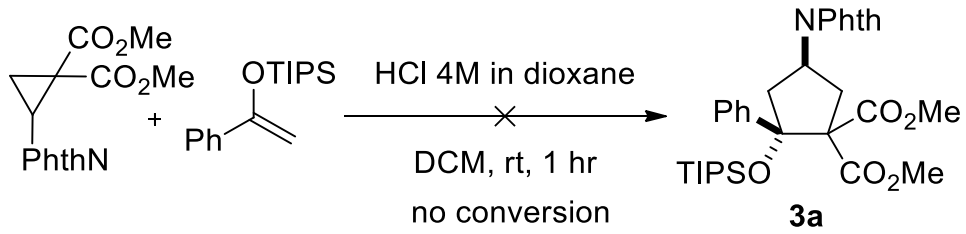
Opening of enantioenriched cyclopentylamines:

Indium (III) trifluoromethanesulfonate (3.5 mg, 0.0062 mmol, 20 mol %) is weighted in the glovebox. The flask is closed with a septum and put under N_2 atmosphere. A solution of **6fa** (18.1 mg, 0.031 mmol, 1 eq) in 0.3 mL of dry dichloromethane (0.15 M) is added. The reaction is stirred overnight at room temperature. The reaction is filtered through a plug of silica in order to remove the catalyst and concentrated under reduced pressure. Purification by column chromatography (6:4 Hexane/Ethyl Acetate) furnished 7.2 mg (0.017 mmol, 55 % yield) of the desired product as a colorless oil.

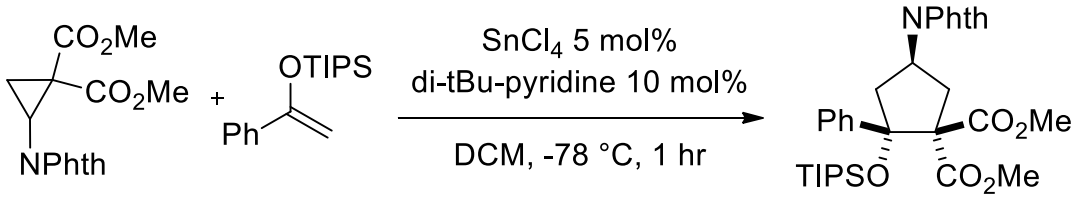


%ee **6fa**	Yield %[a]	%ee **7fa**
98	55	98

Control Experiments

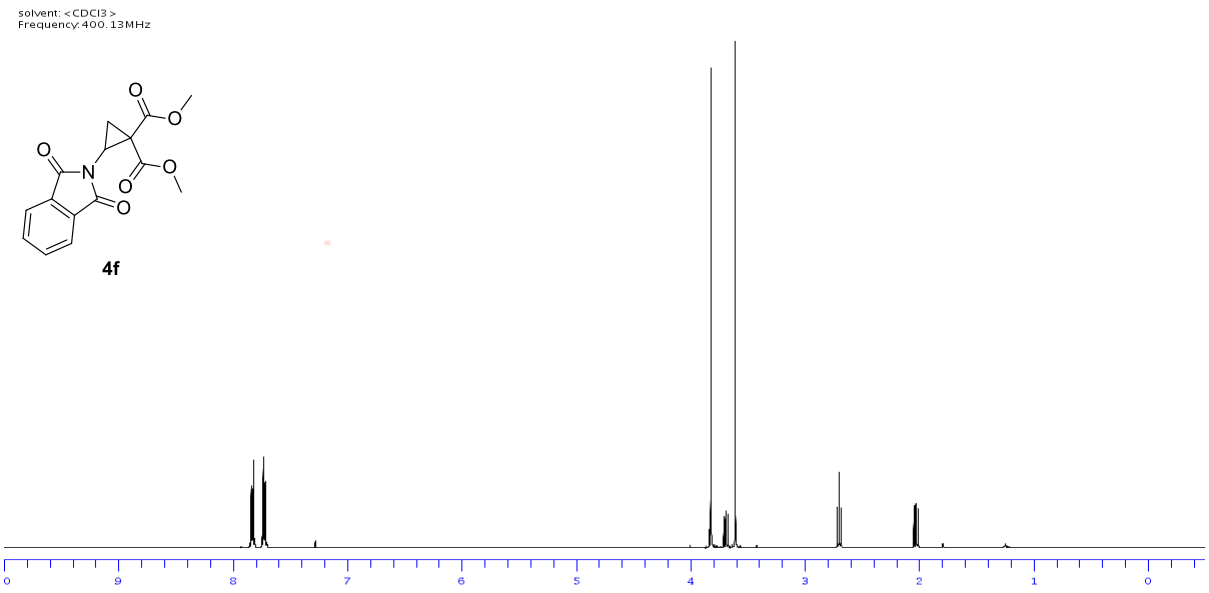


To a solution of aminocyclopropane (30 mg, 0.098 mmol, 1 eq) and silyl enol ether (41 mg, 0.15 mmol, 1.5 eq) in 0.3 mL of dry dichloromethane under nitrogen, is added 5.0 µl (0.019 mmol, 20 mol %) of a 4M HCl in dioxane solution at room temperature. The reaction is stirred at room temperature for 12 hours and no evolution of the starting material could be observed.



In an oven-dried flask sealed with a septum and under N_2 atmosphere is added 50 mg of N-phthalimide aminocyclopropane (0.16 mmol, 1 eq), 68 mg of silyl-enol ether (0.25 mmol, 1.5 eq) and 3.1 mg of 2,6-Di-tert-butylpyridine (0.016 mmol, 10 mol%) in 0.5 mL of dry dichloromethane. The solution is cooled down to -78 °C and 19.2 µL of a 0.43 M solution of tin tetrachloride (5 mol %) in dry dichloromethane is added. The reaction is stirred for 1 h at -78 °C. Triethylamine (0.1 mL) is then added in one portion at -78 °C. The reaction is warmed at room temperature and stirred for 15 min. Dichloromethane is removed under reduced pressure and the crude is analyzed by ^{1}H NMR.
Ratio of starting material/product = 2.5:1

Spectra of New Compounds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2
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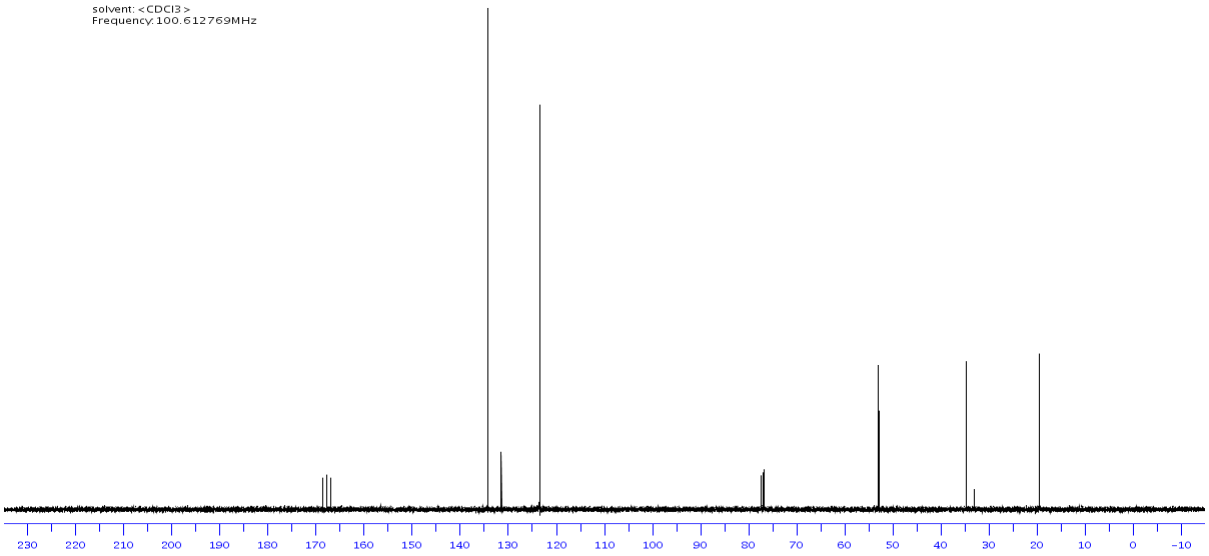
0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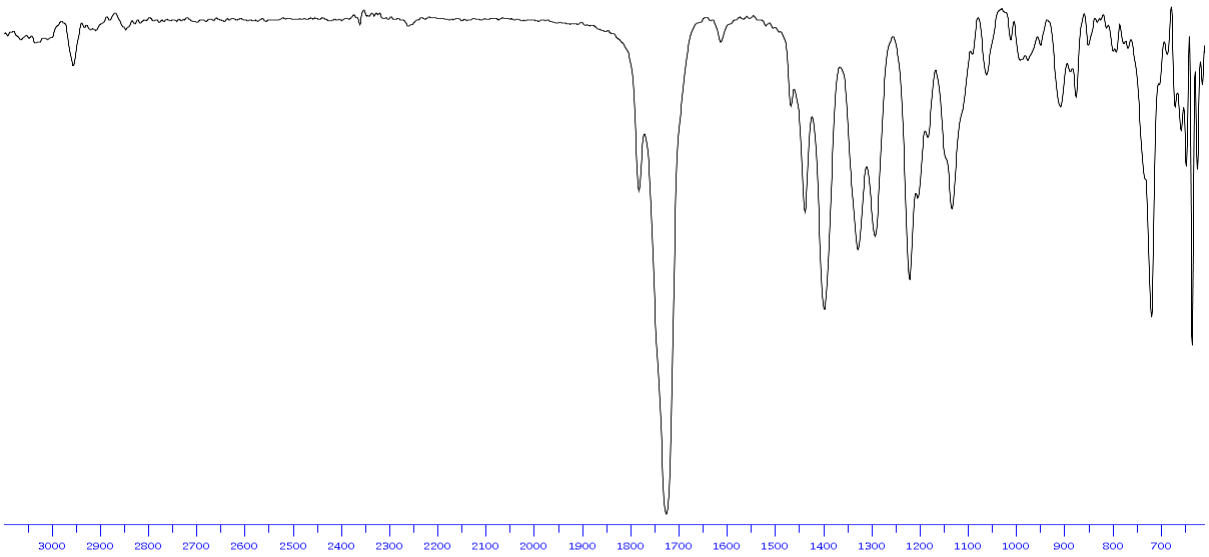
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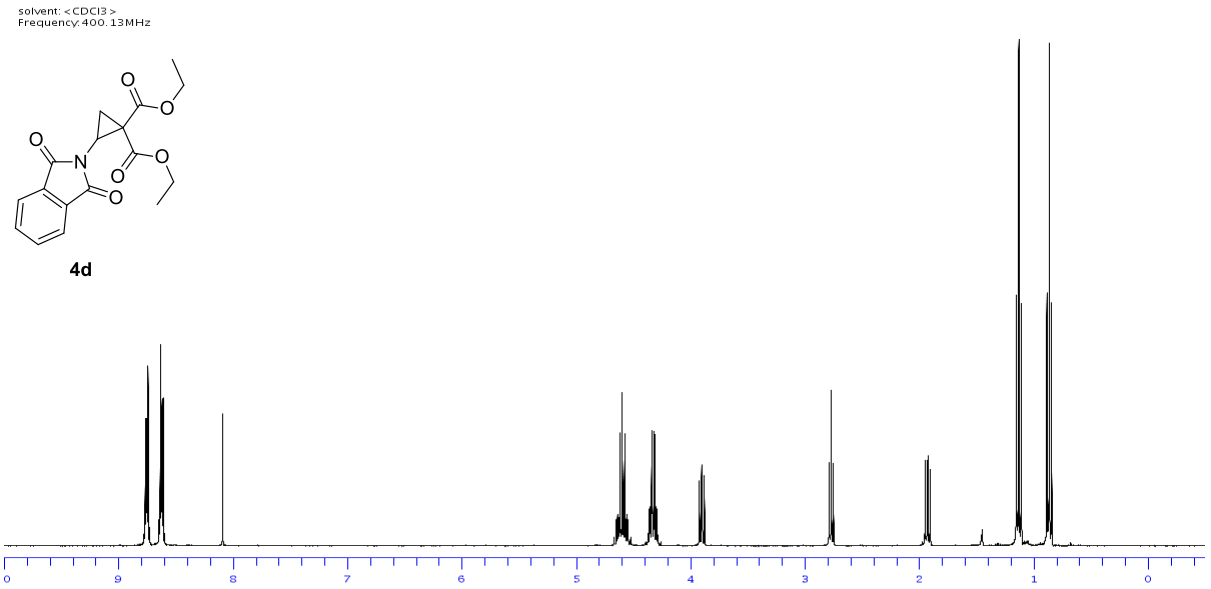
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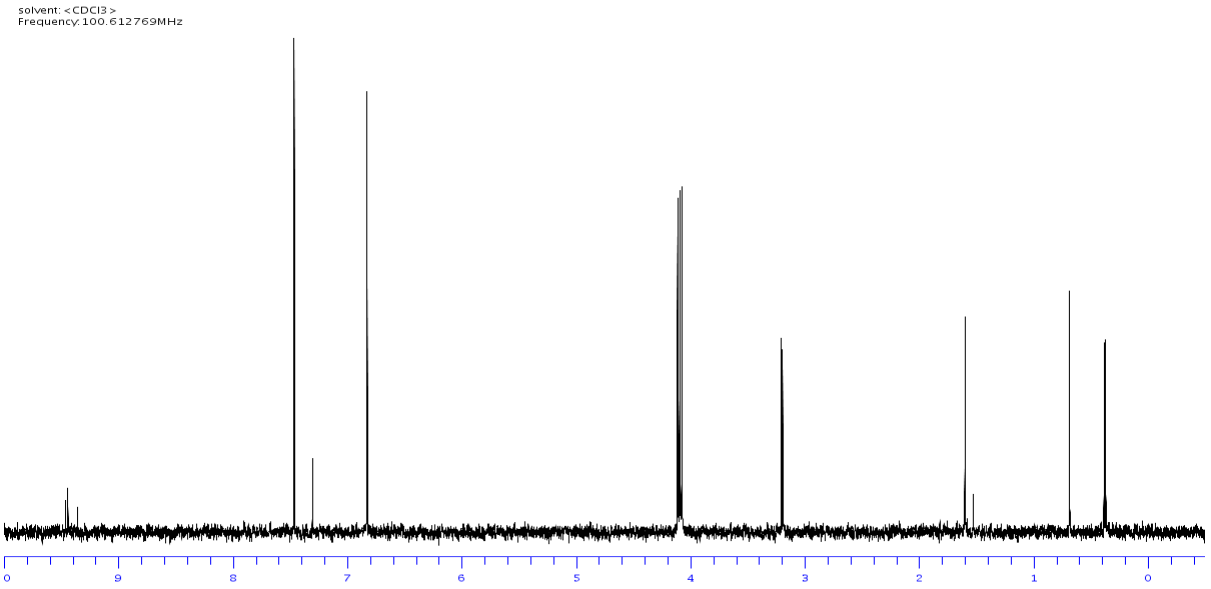
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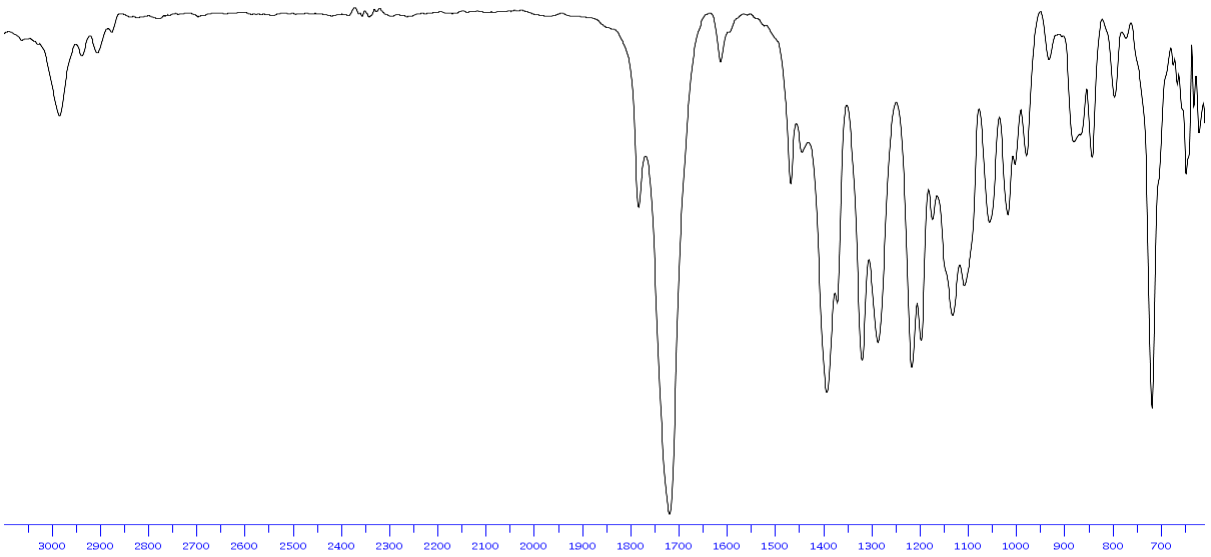
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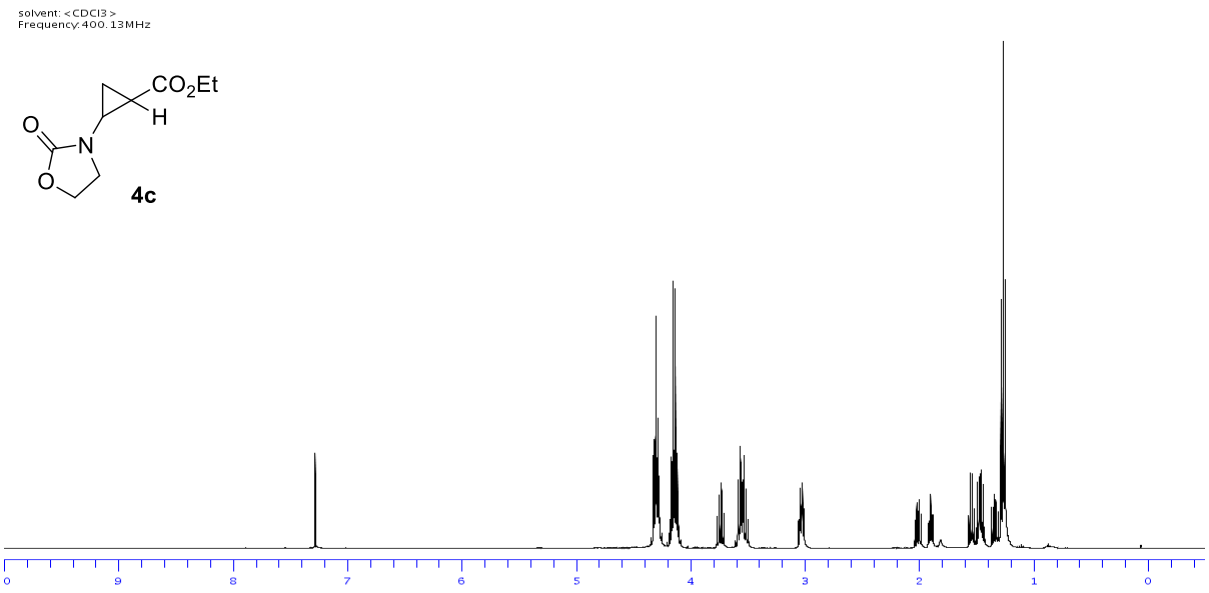
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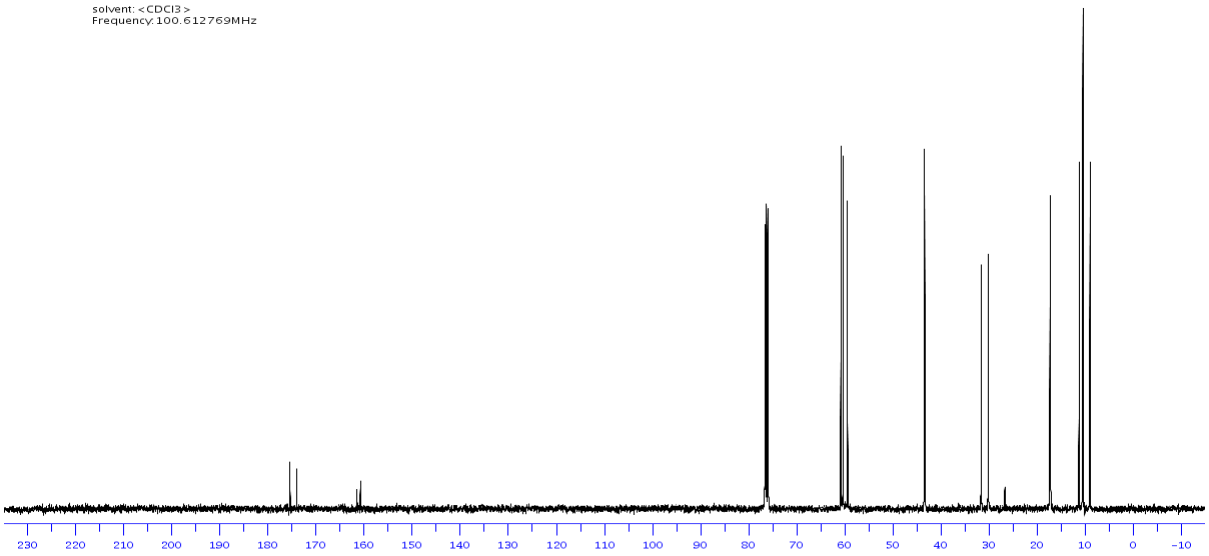
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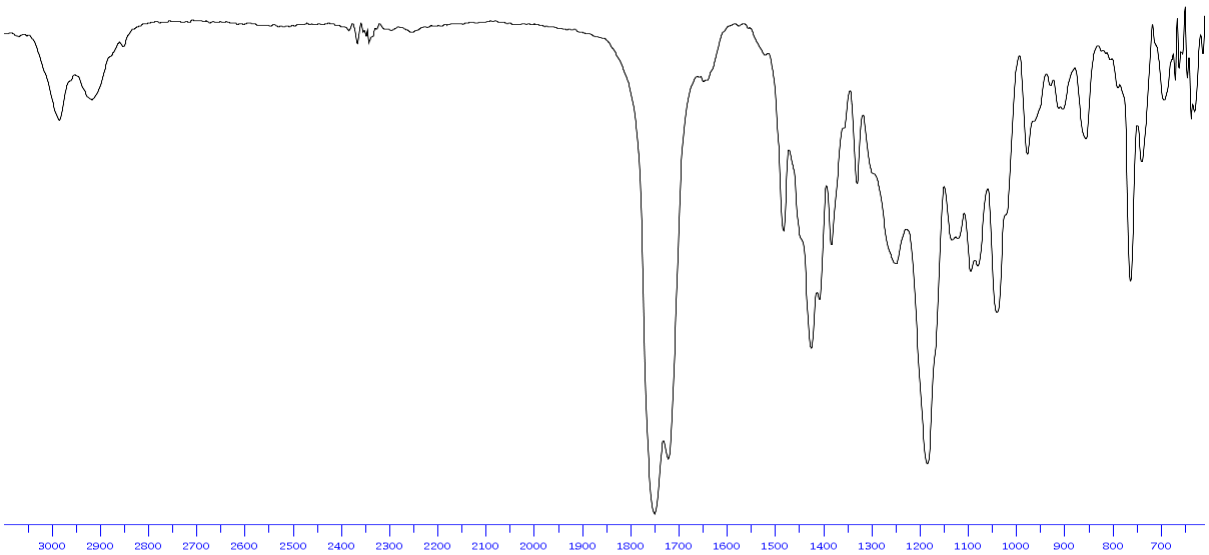
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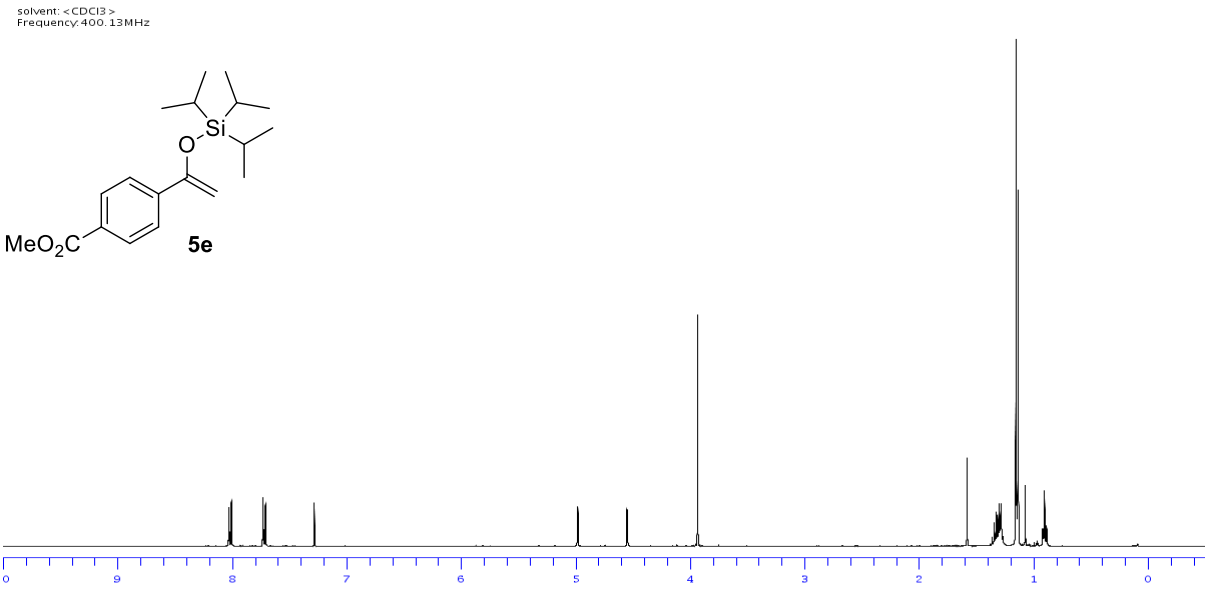
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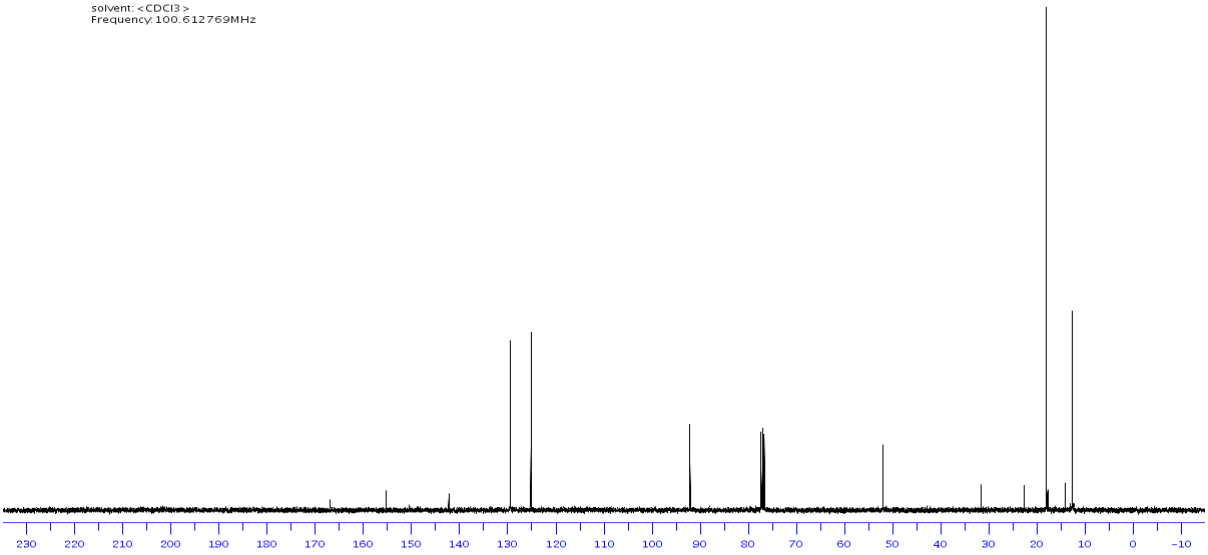
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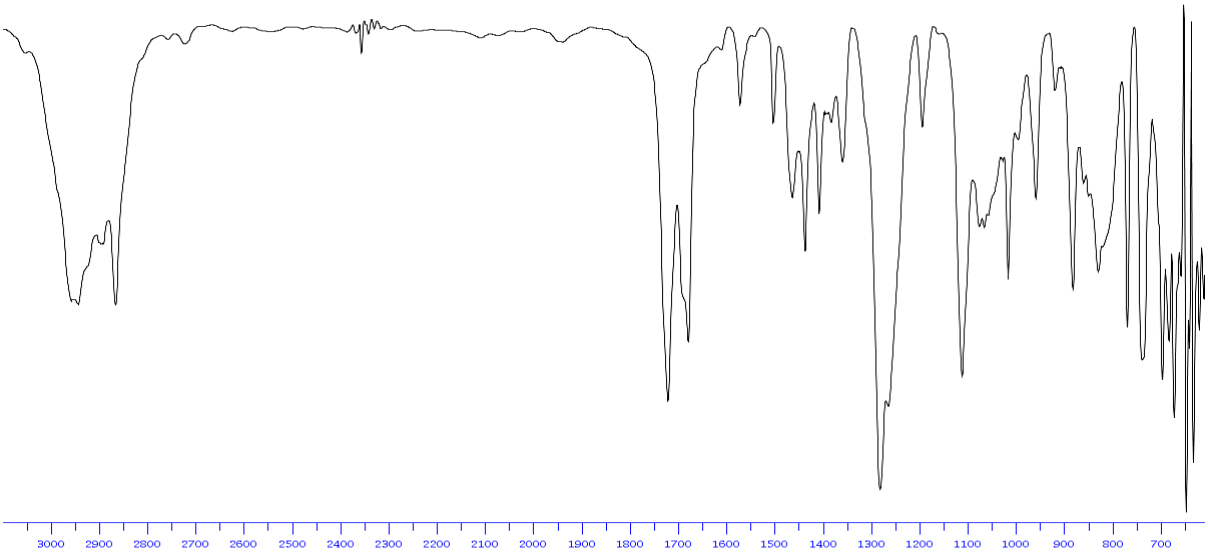
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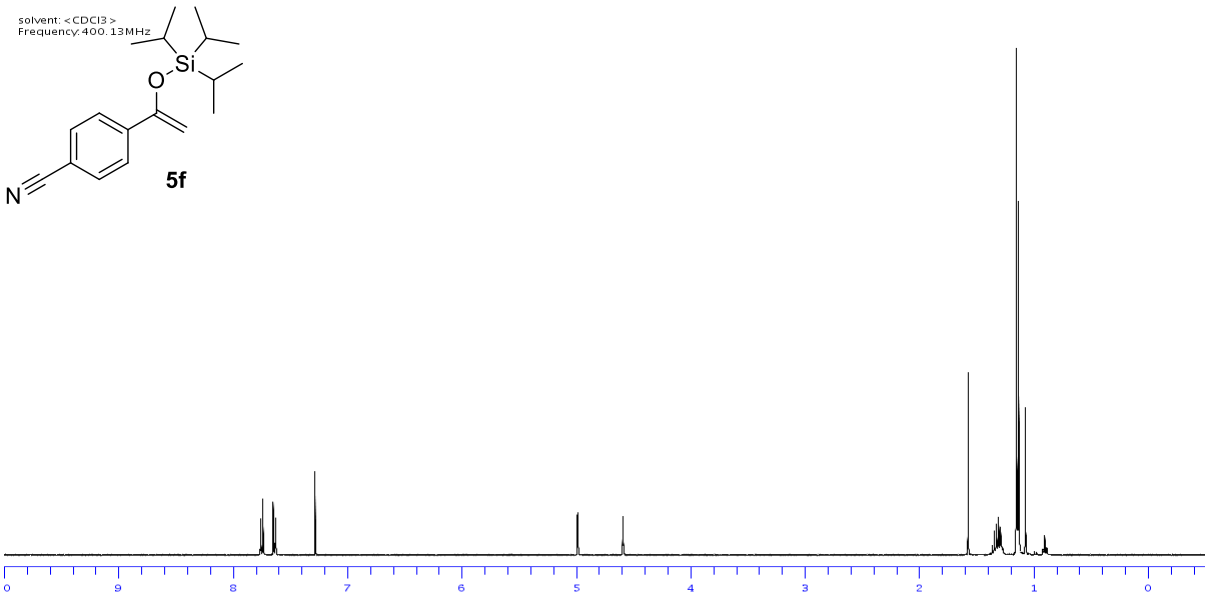
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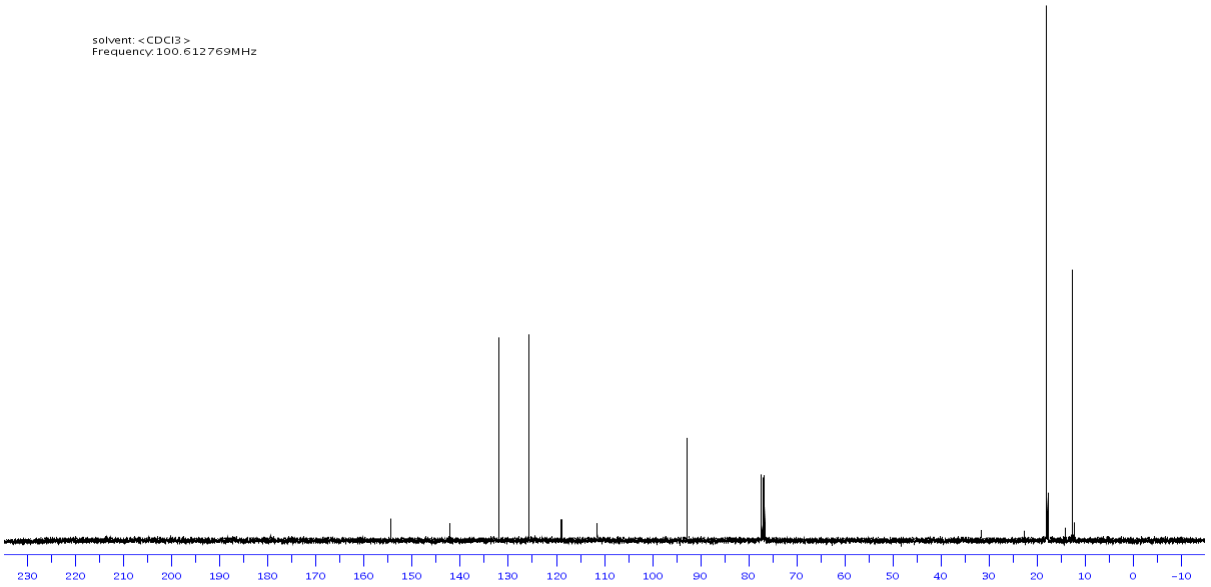
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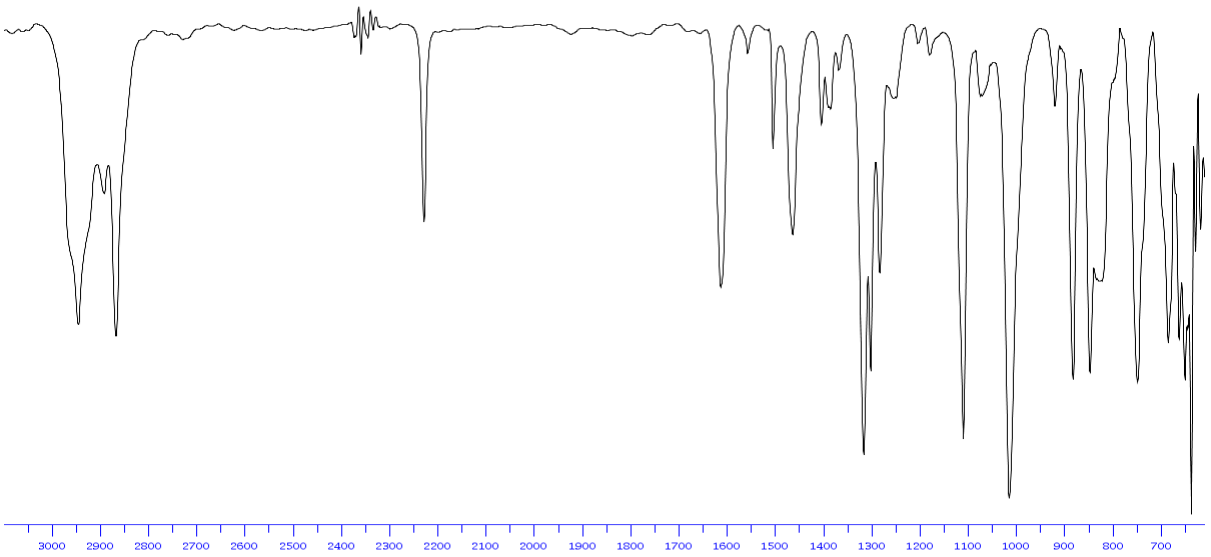
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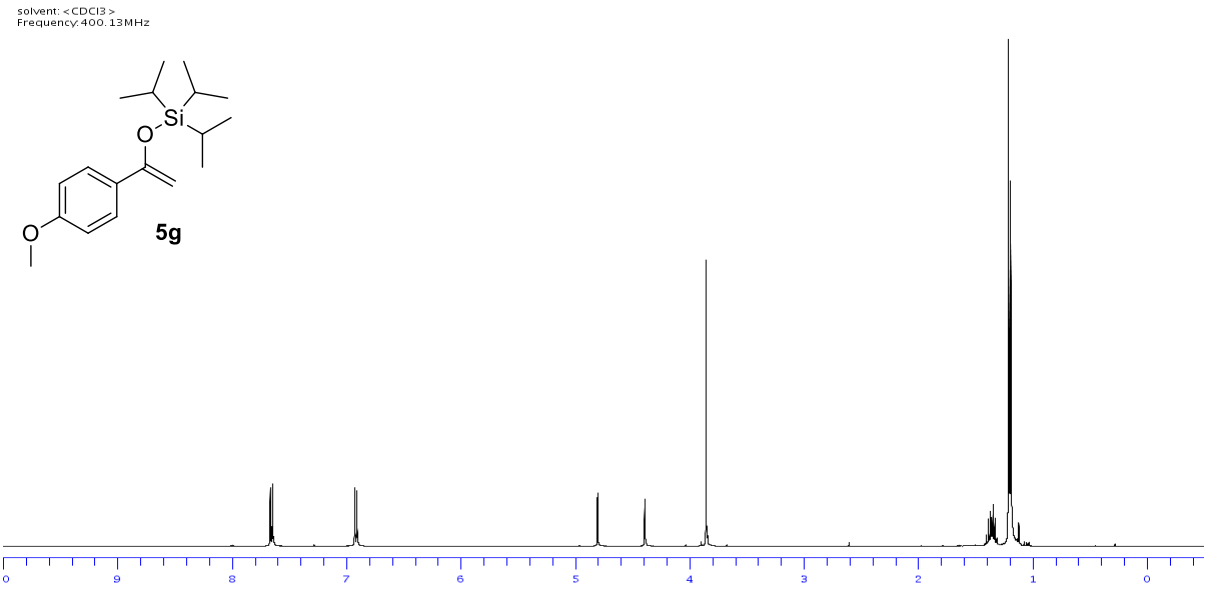
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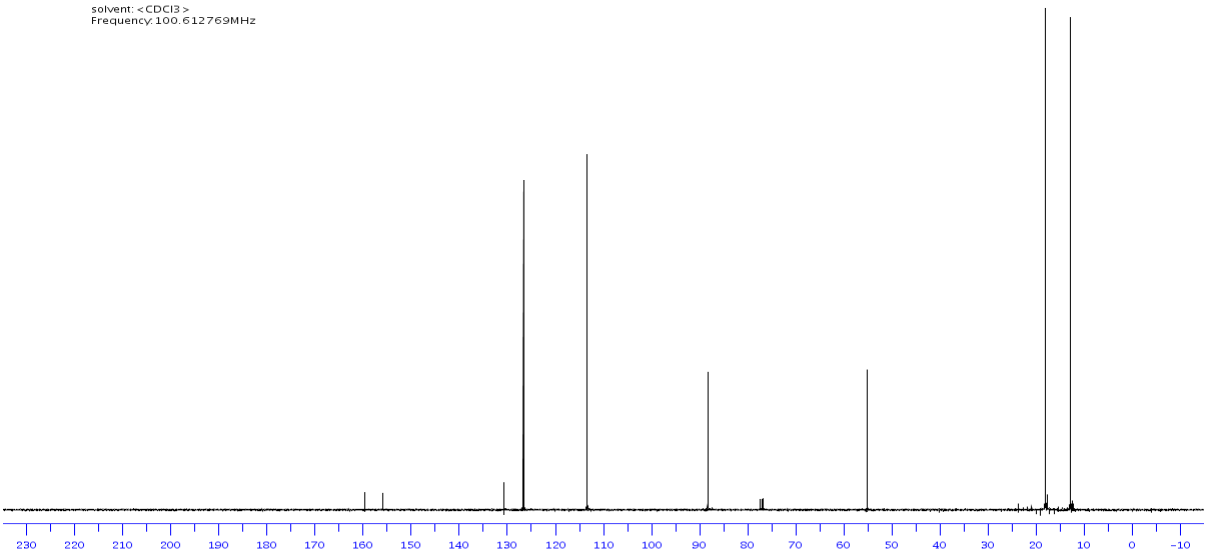
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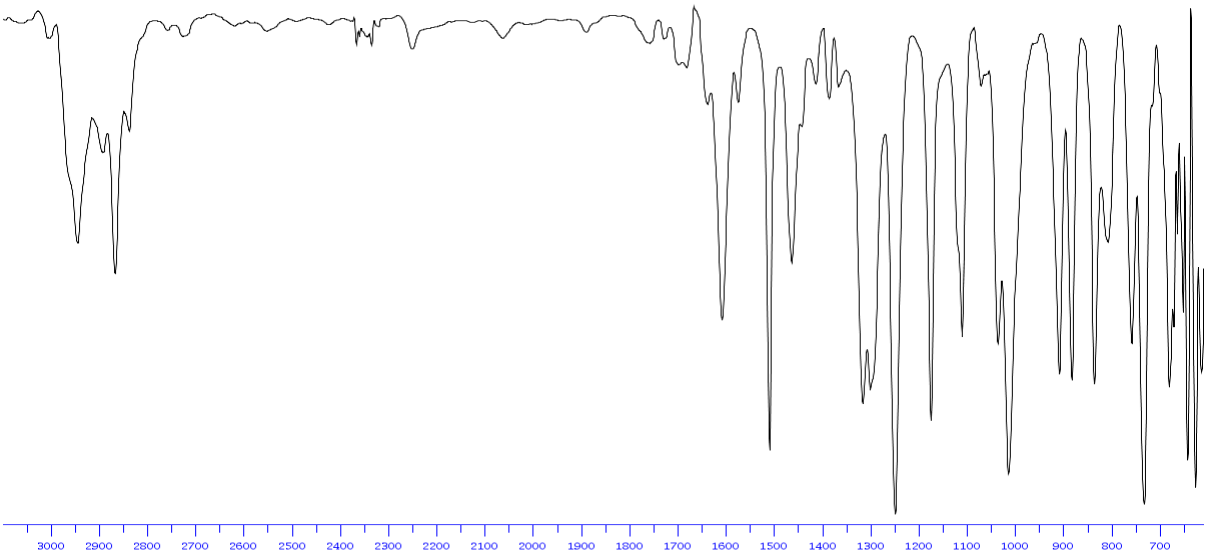
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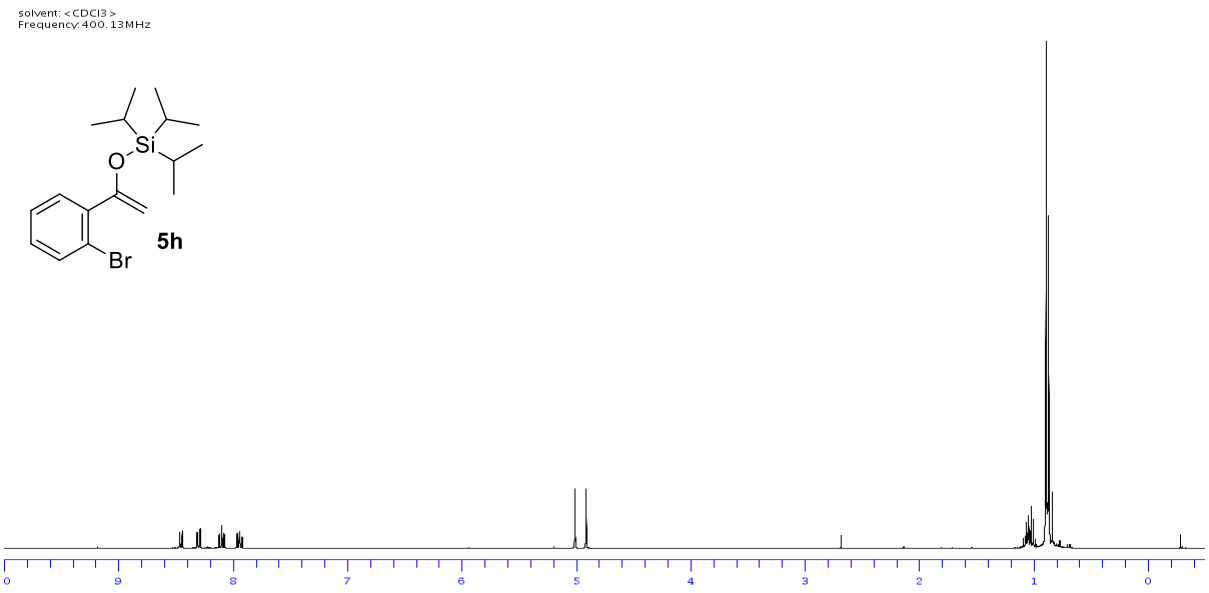
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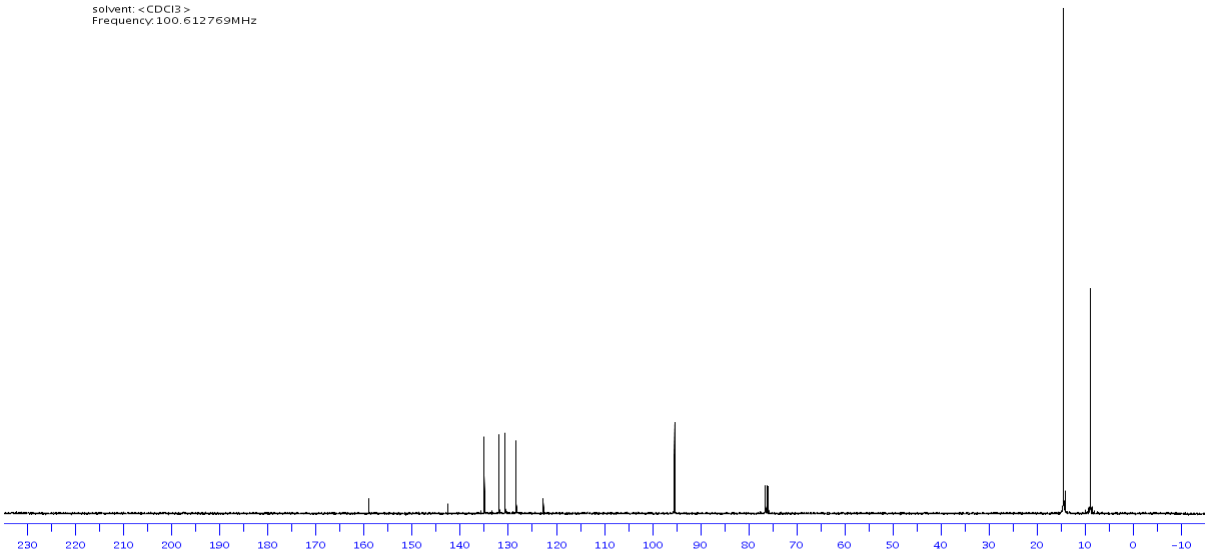
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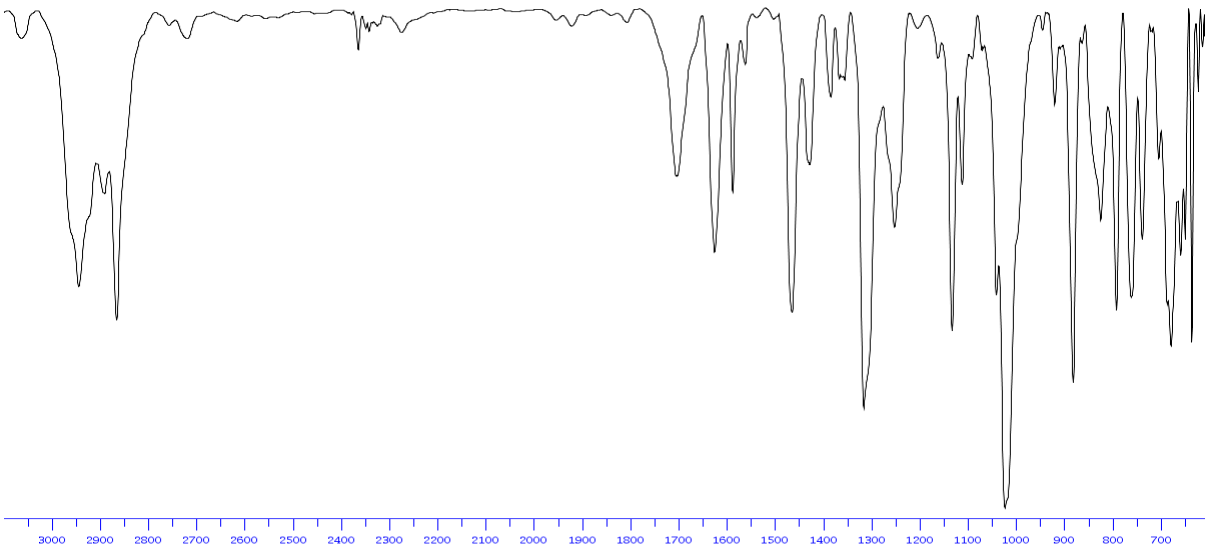
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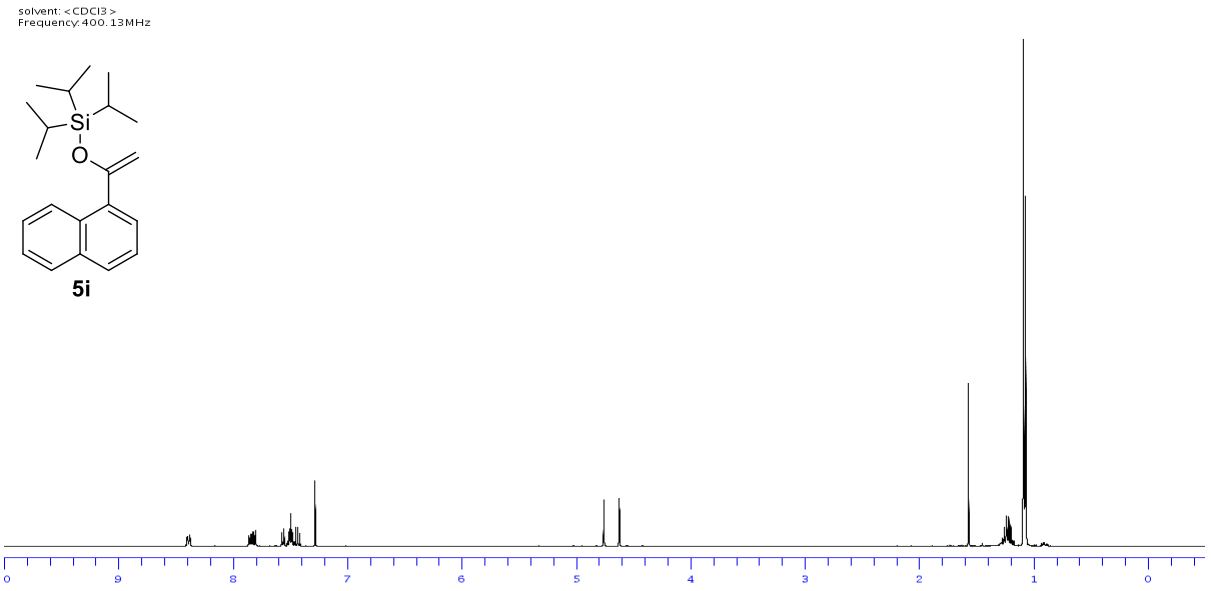
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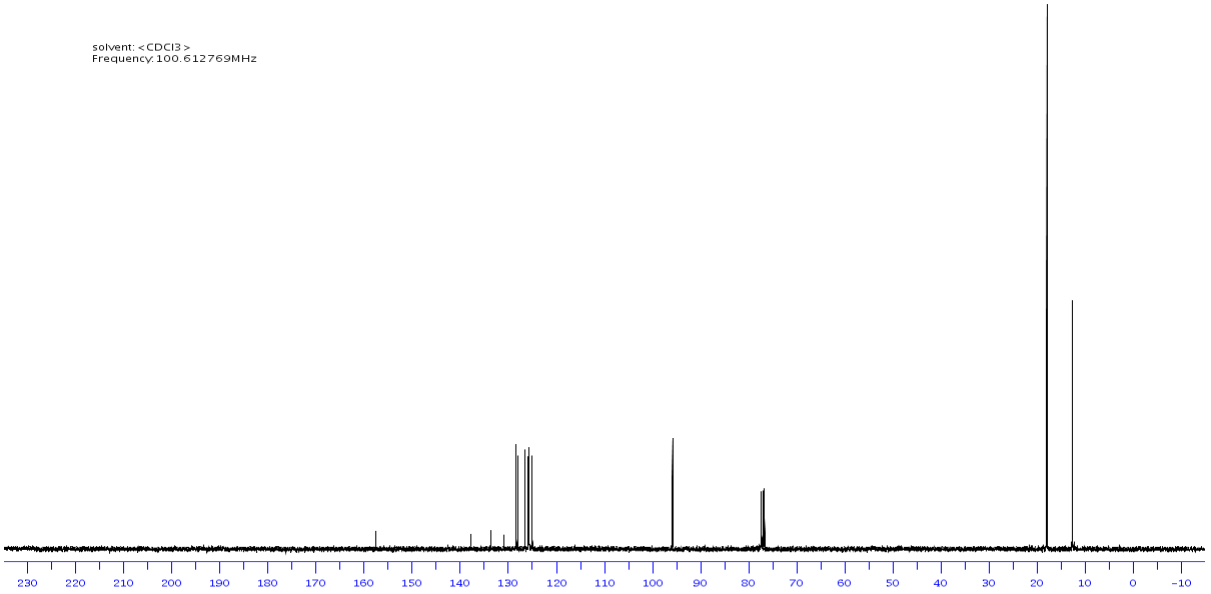
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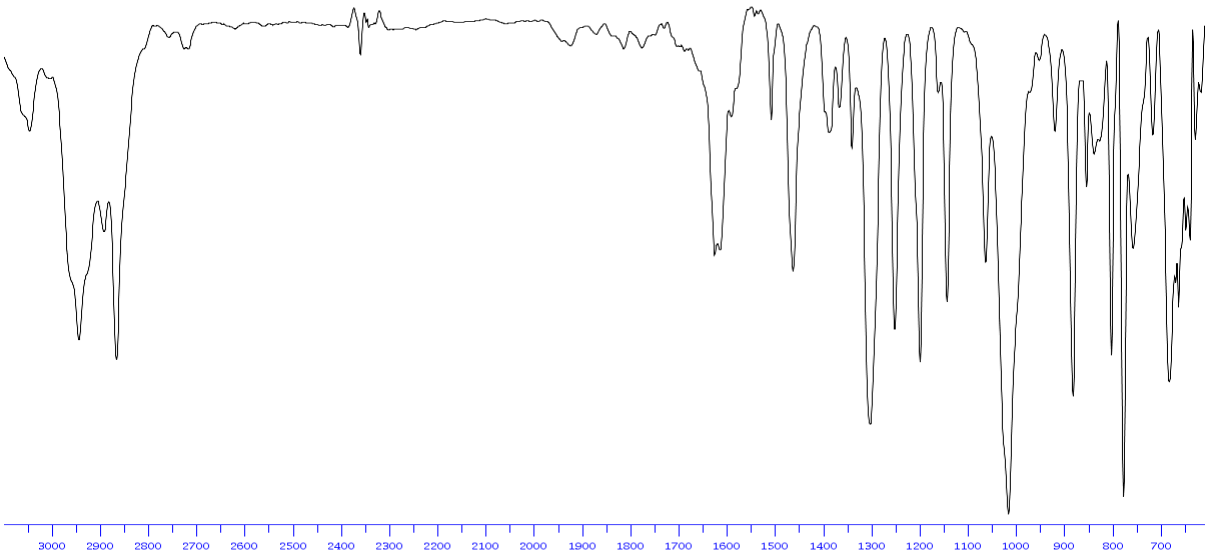

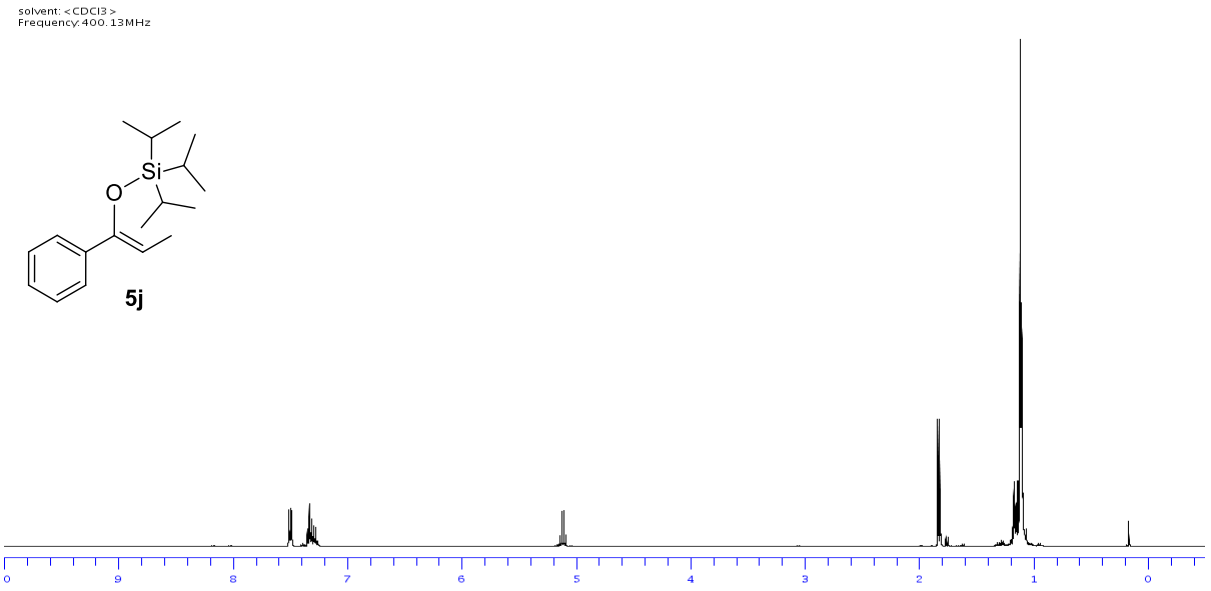
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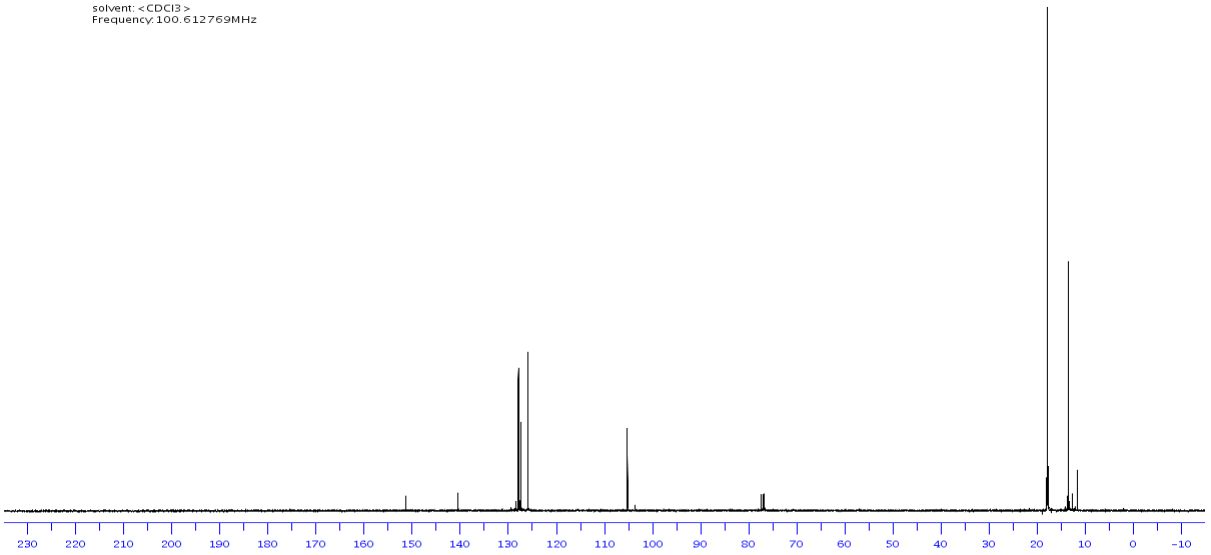
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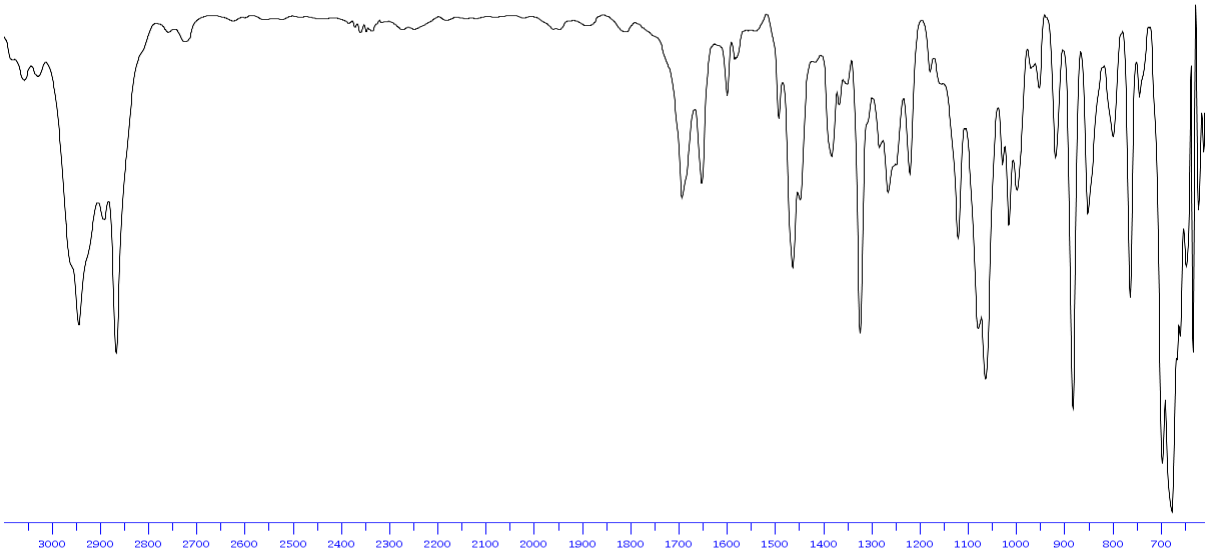
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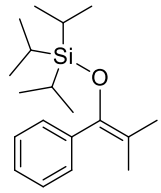

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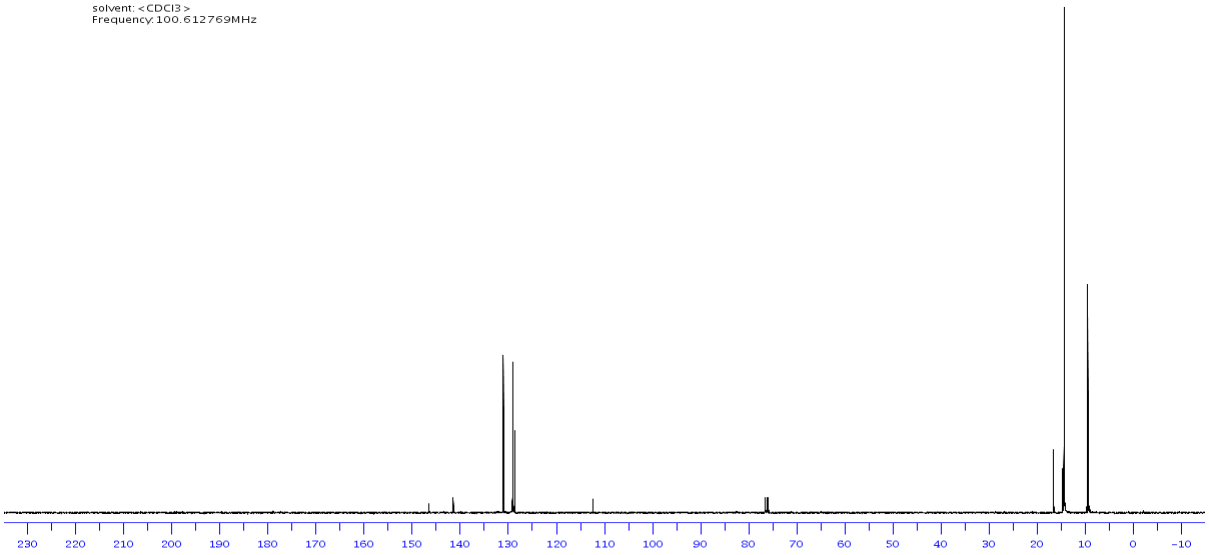

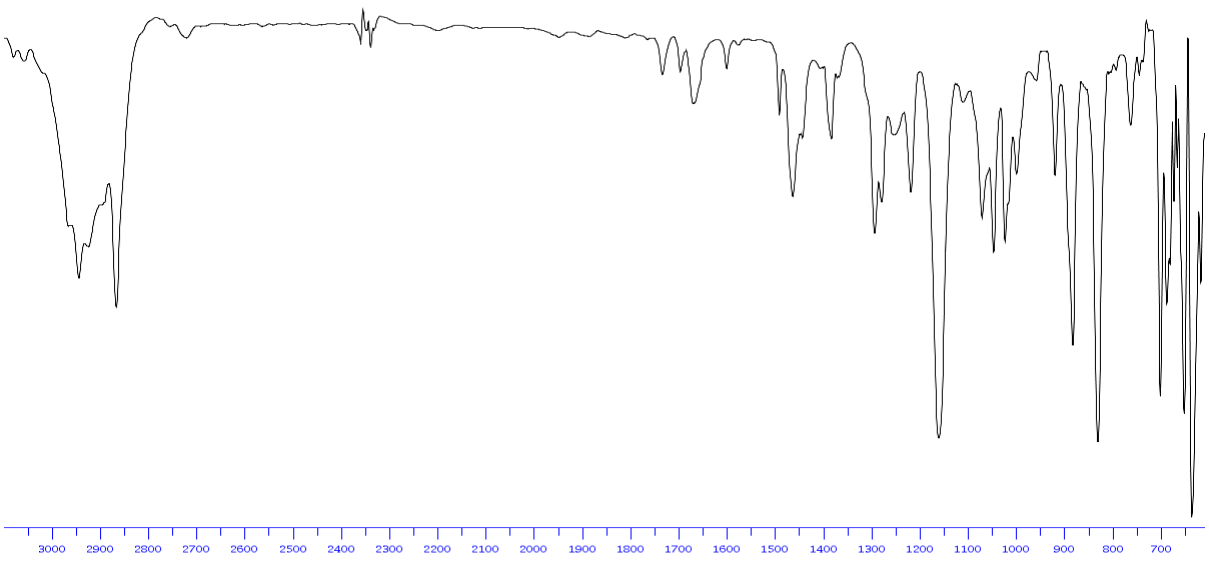

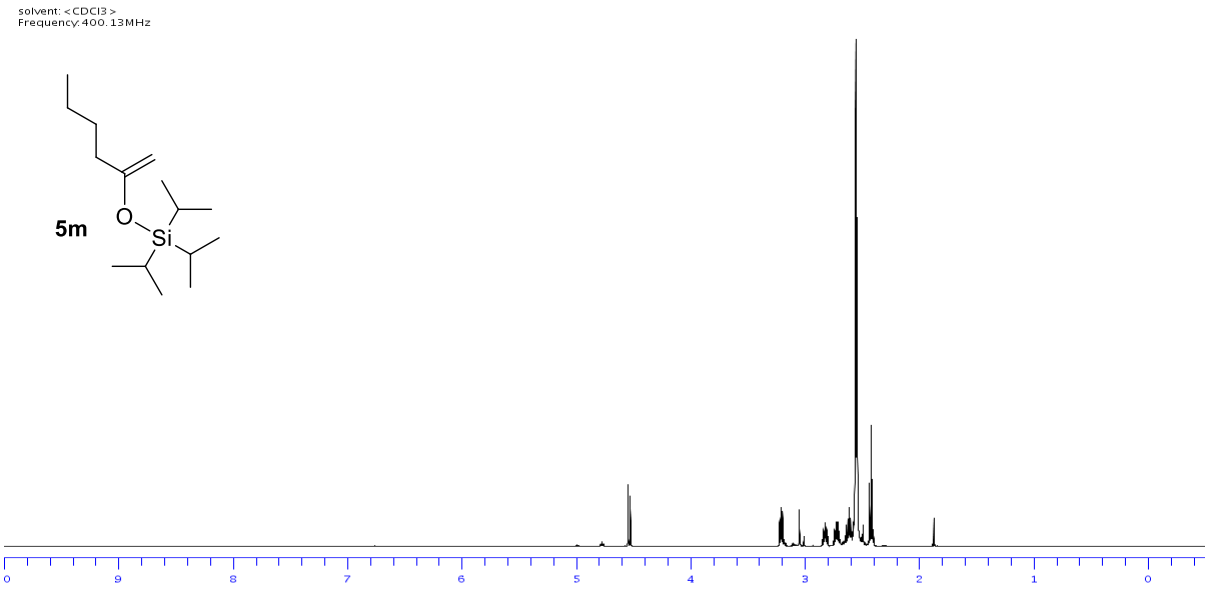
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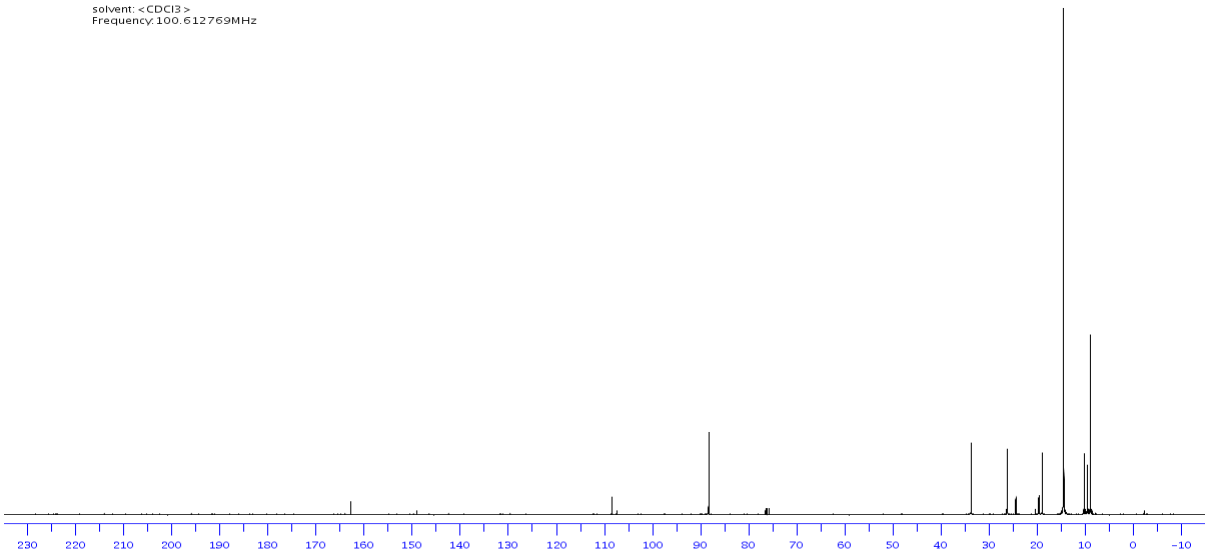
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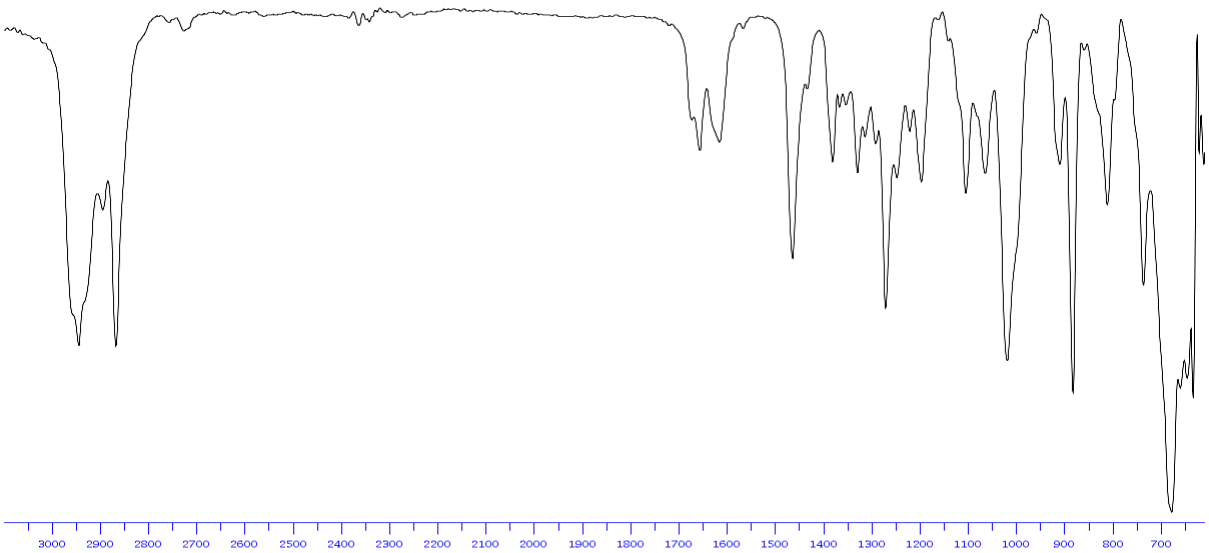
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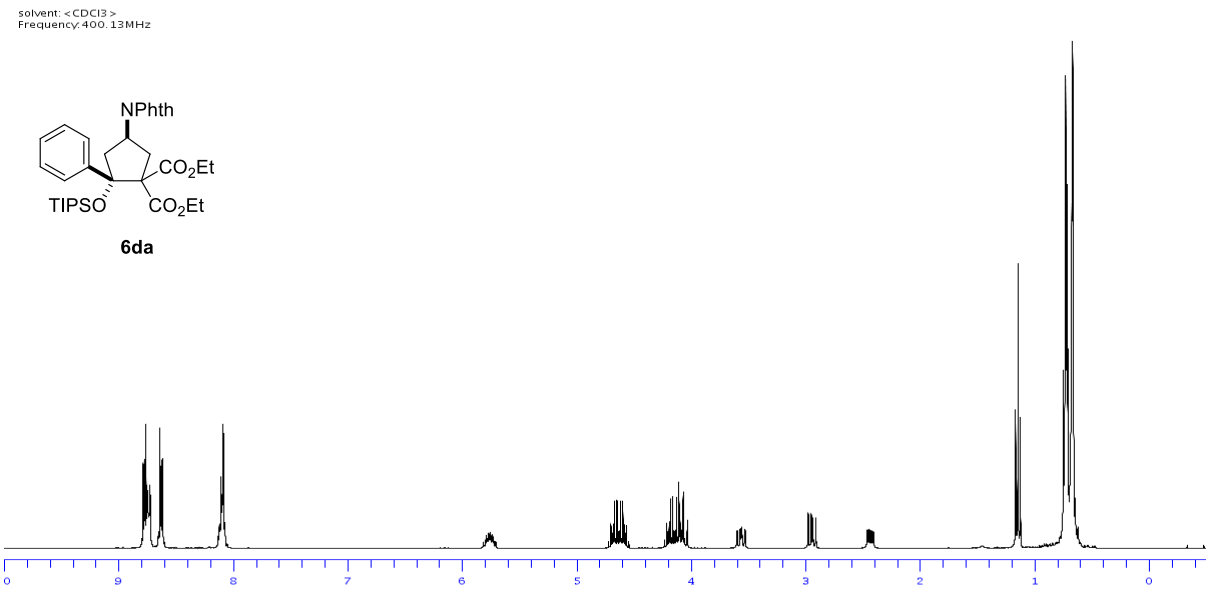
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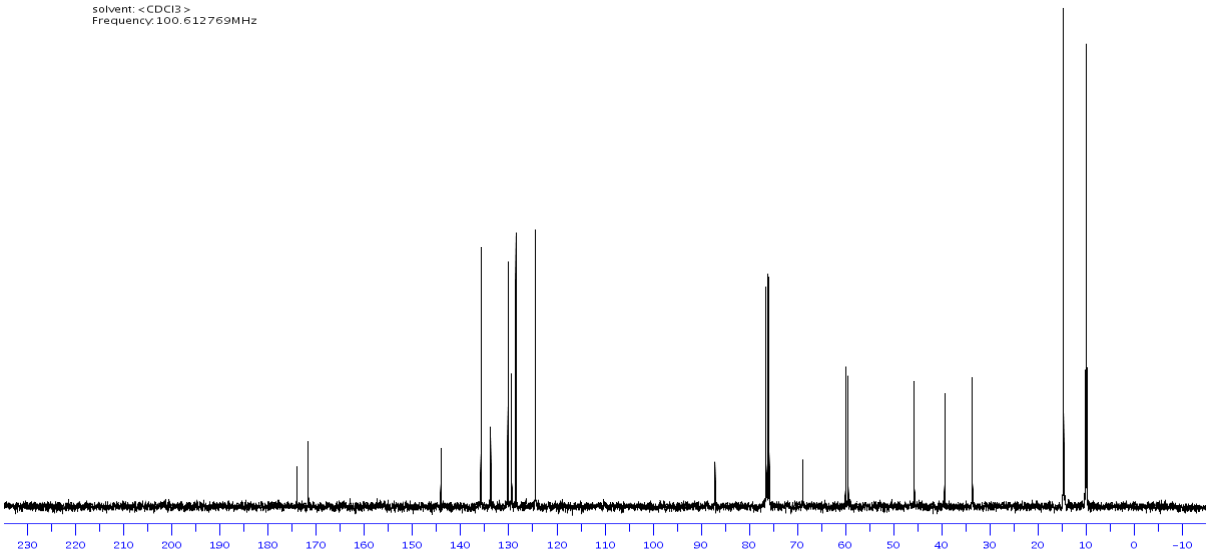
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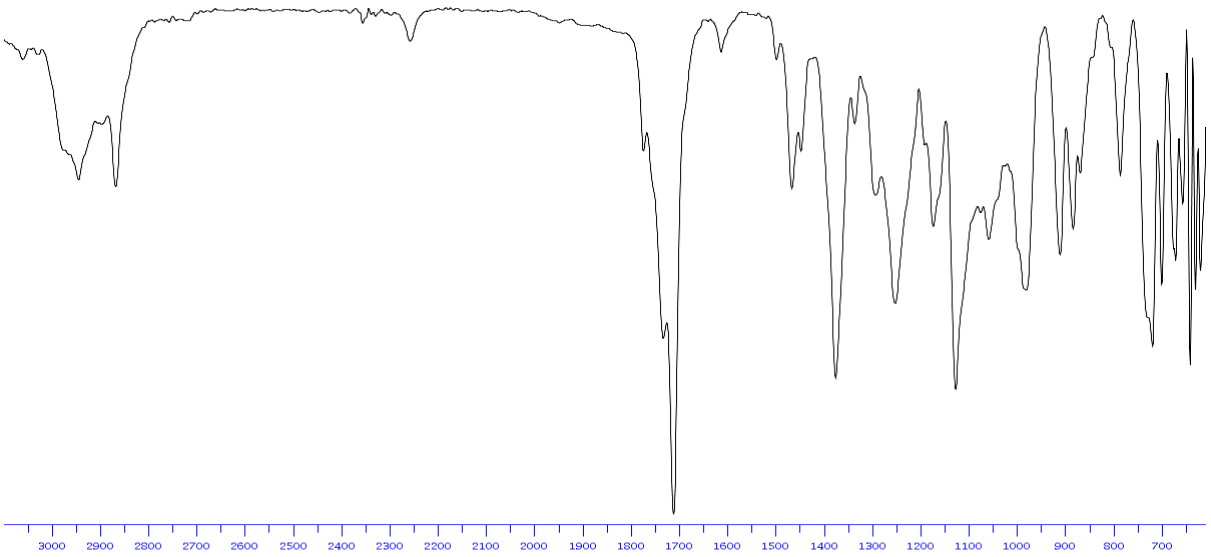

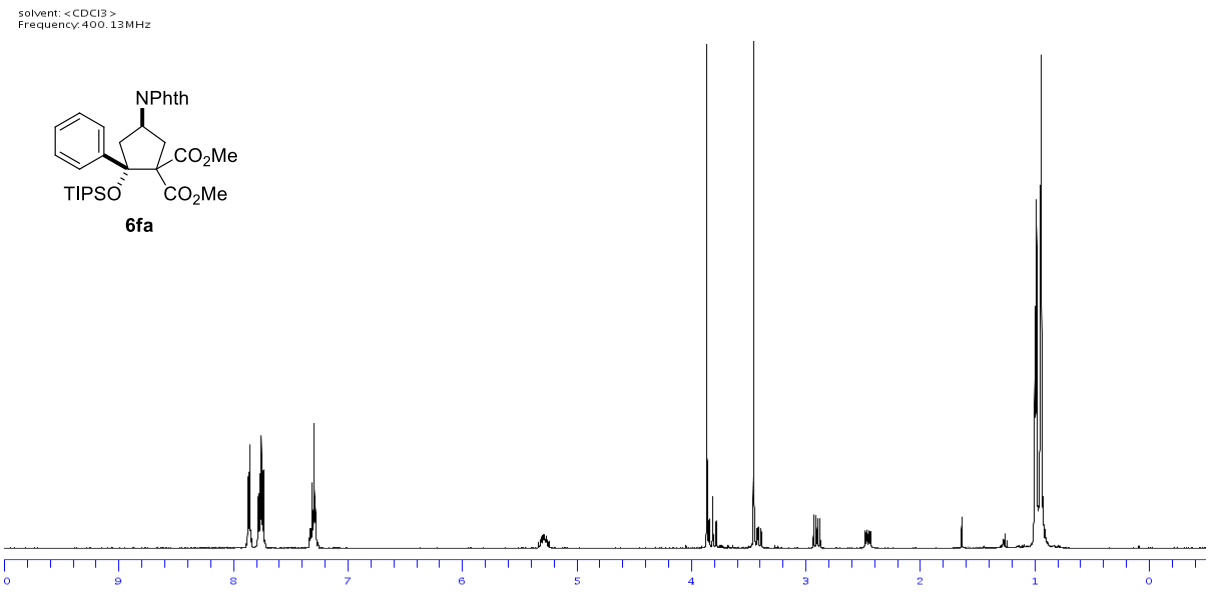
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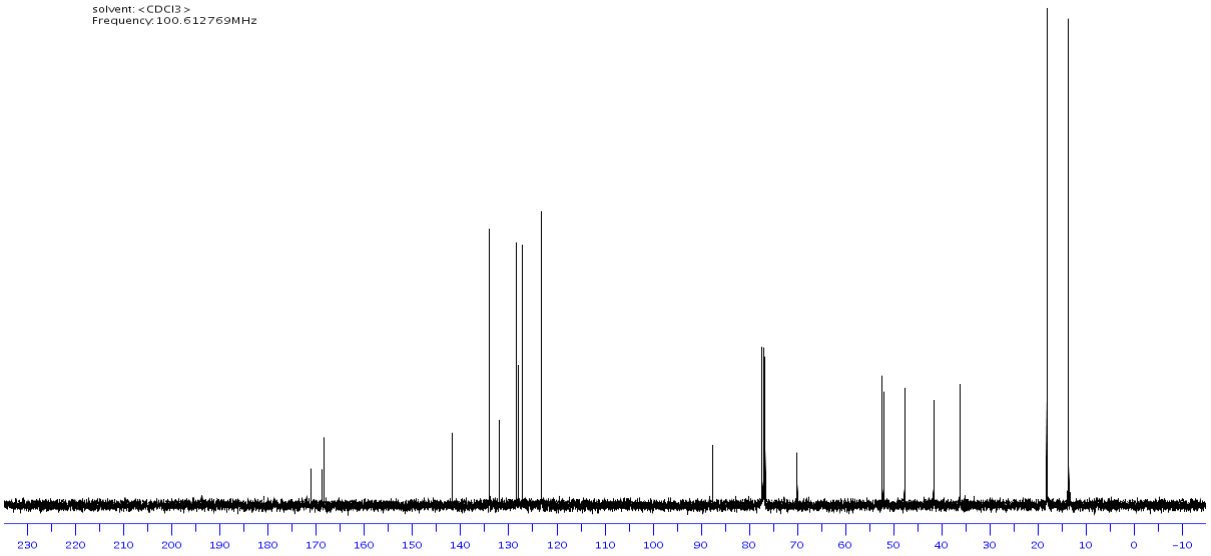
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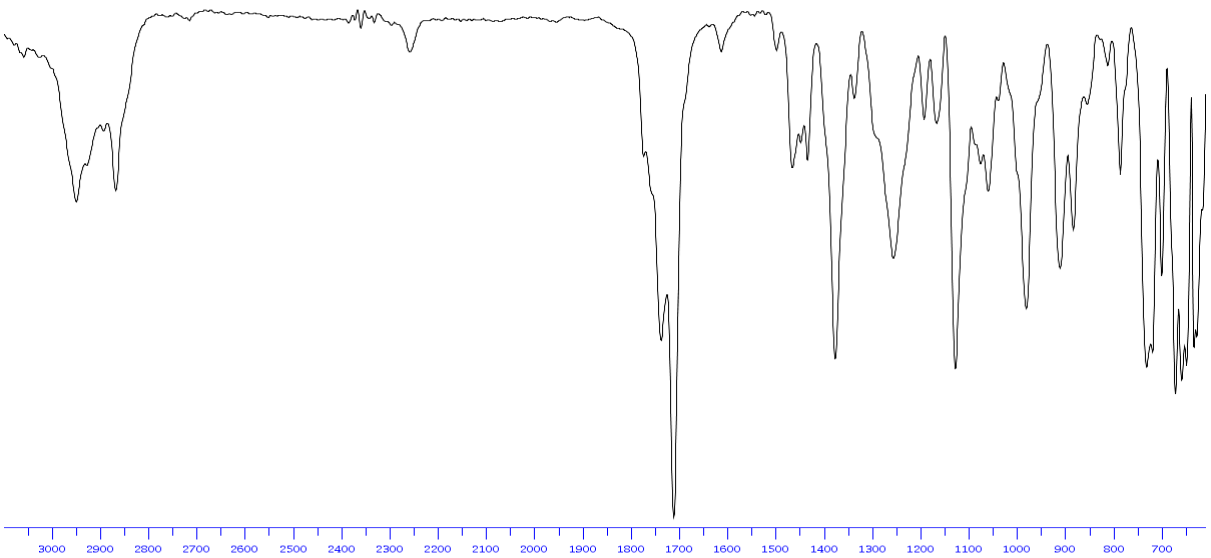

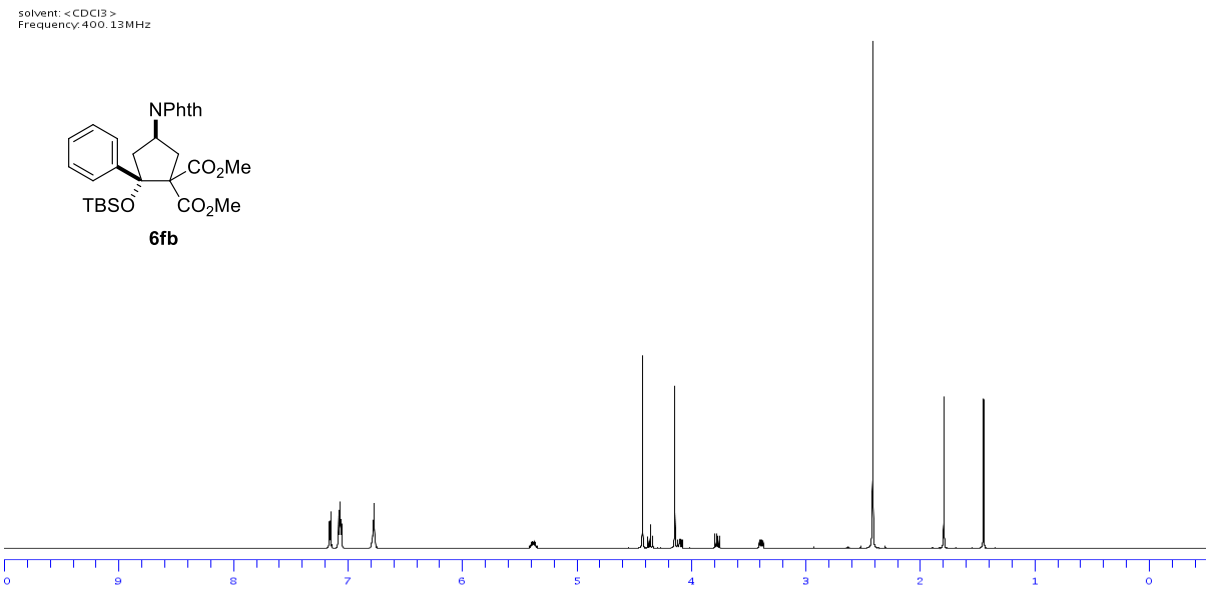
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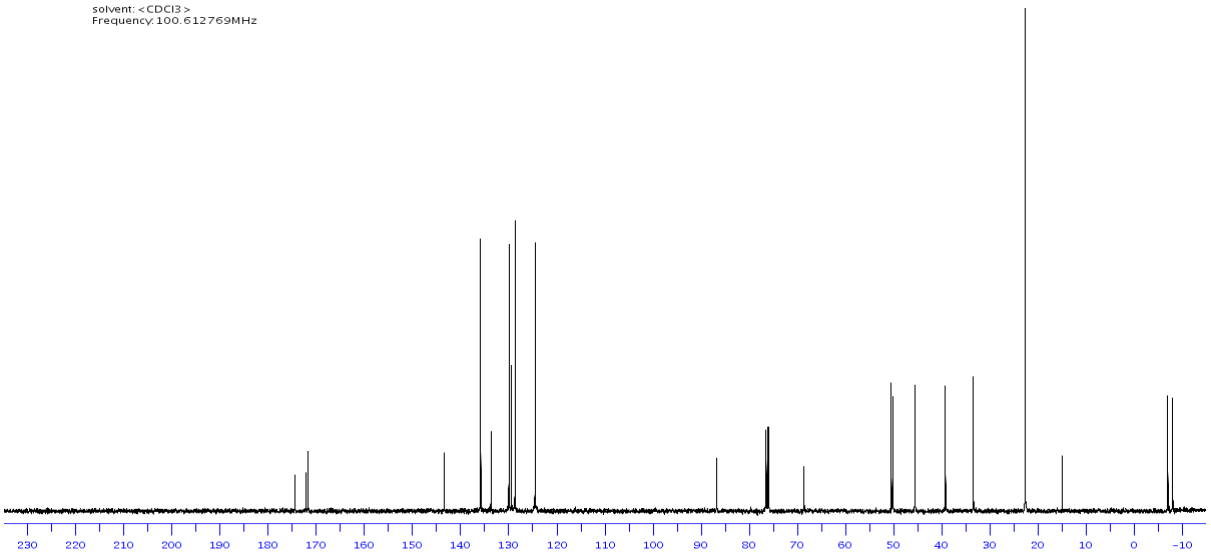
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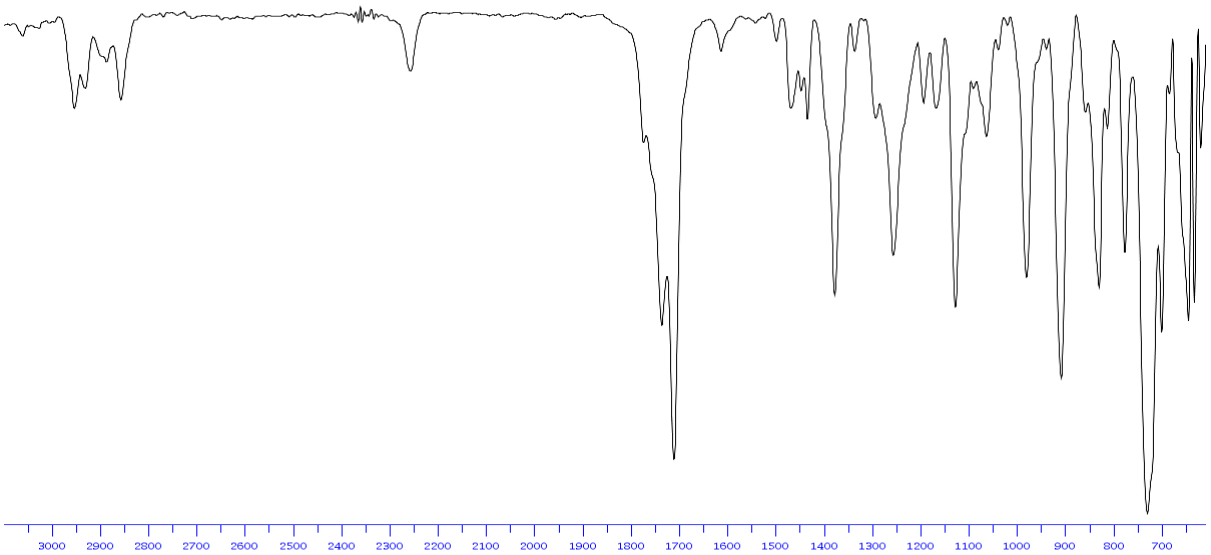

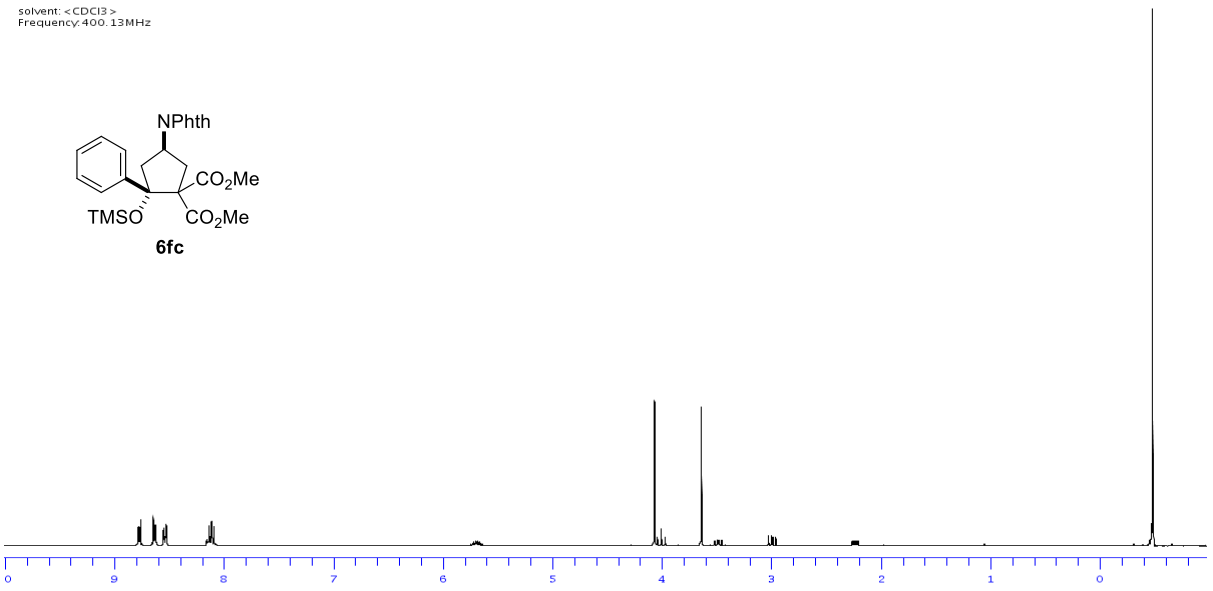
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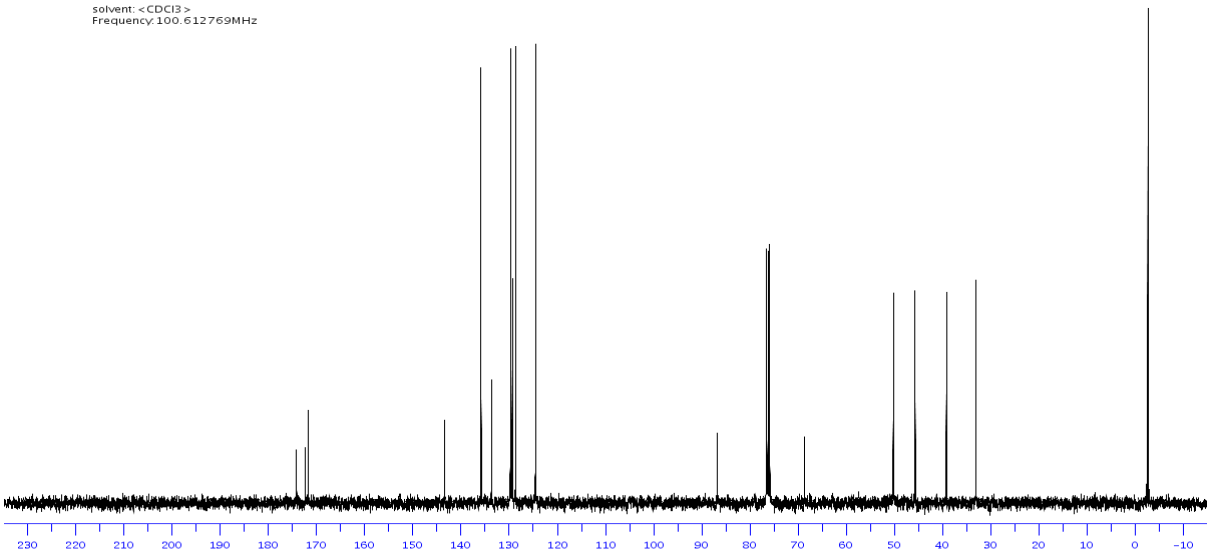
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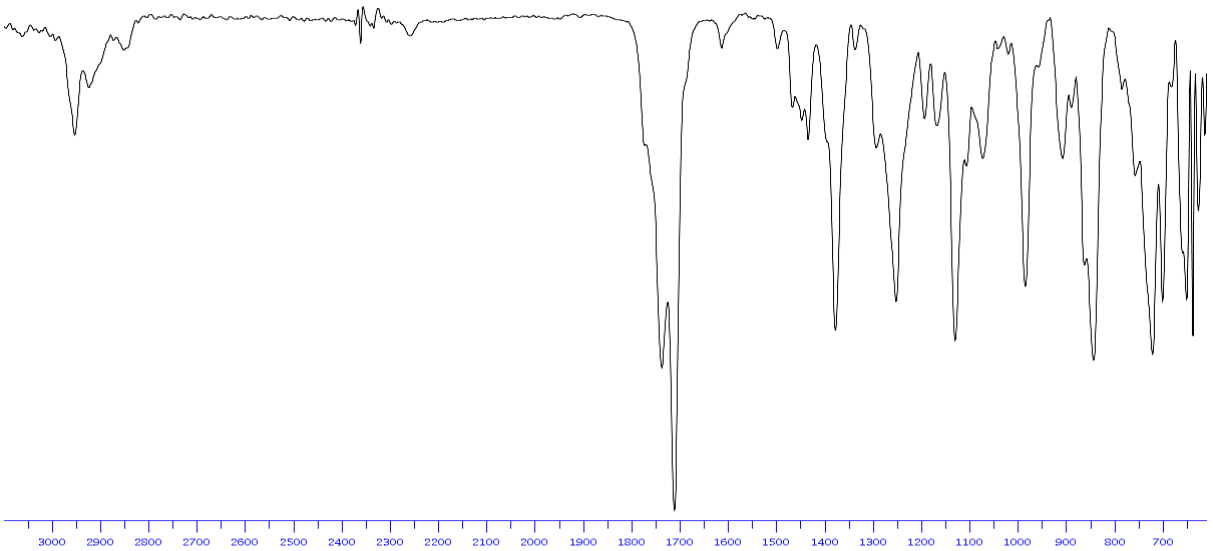

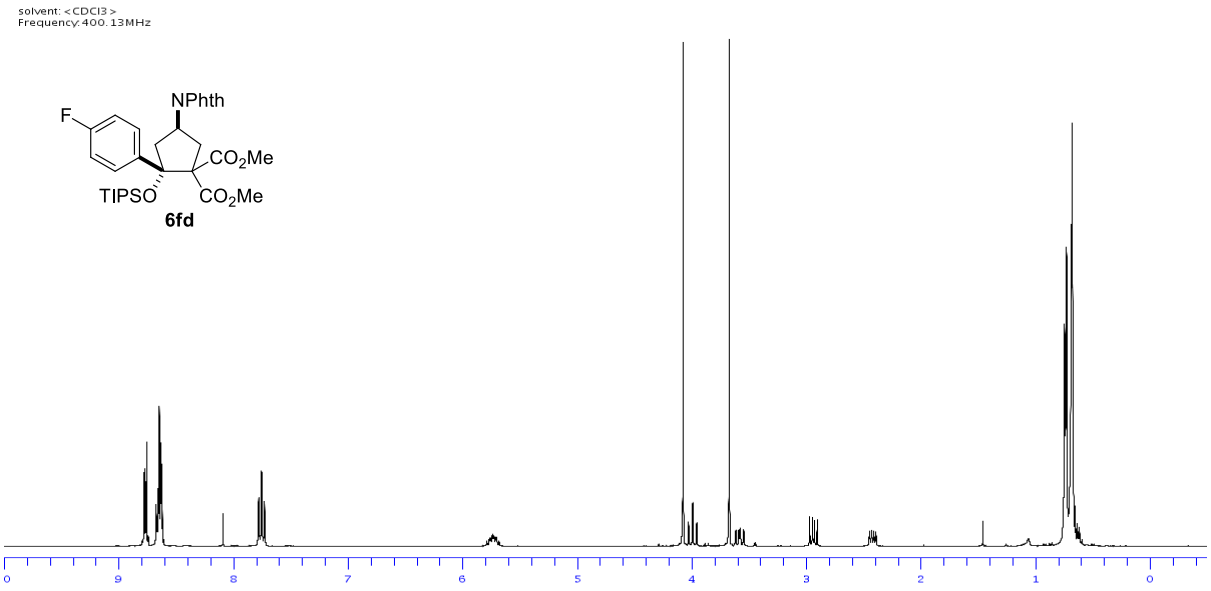
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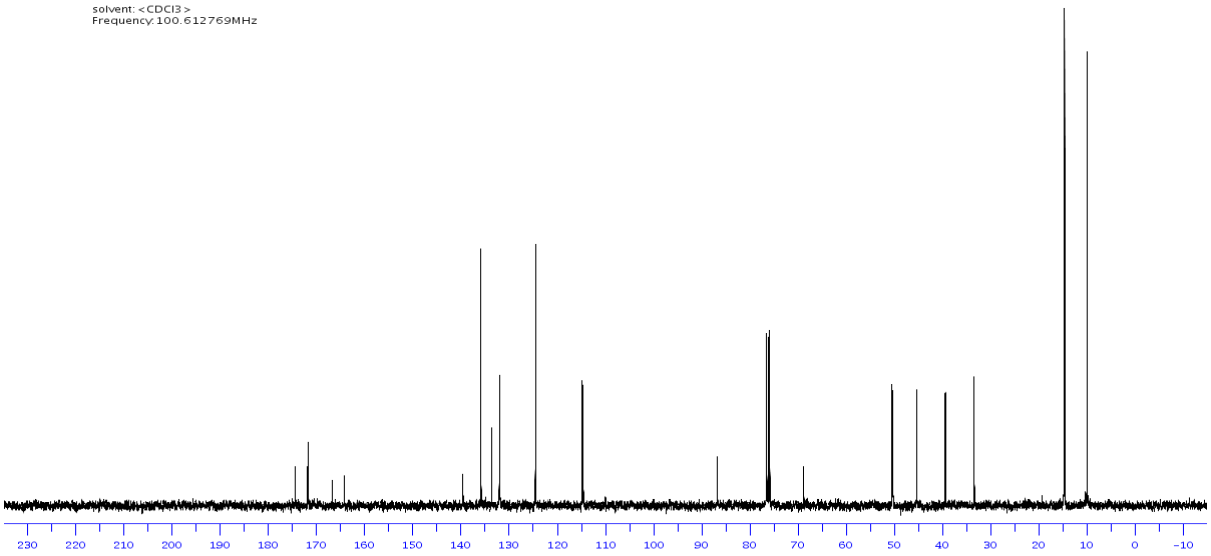
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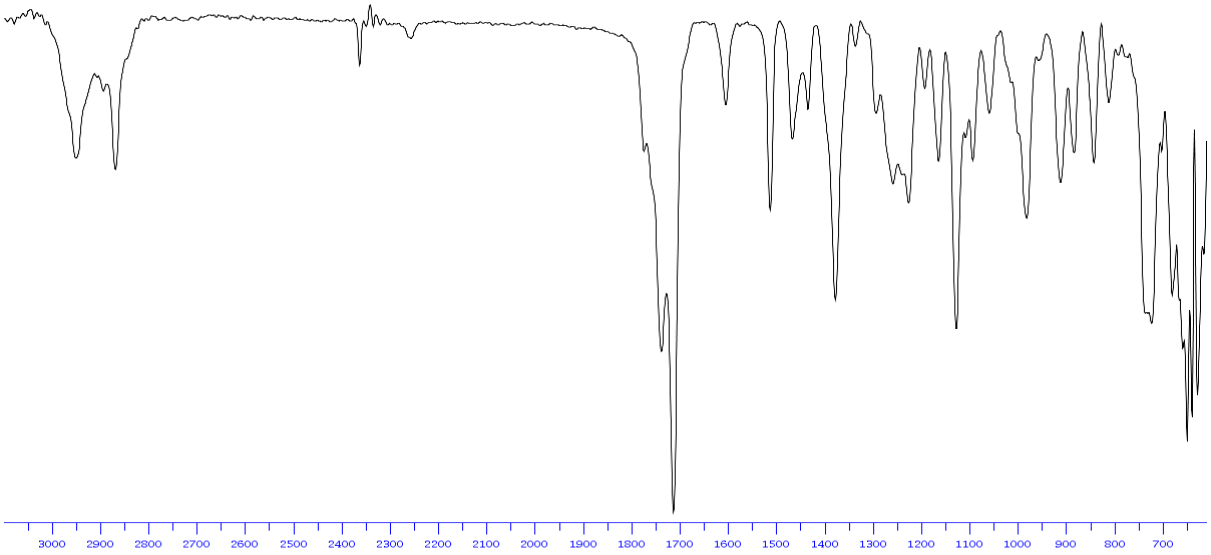

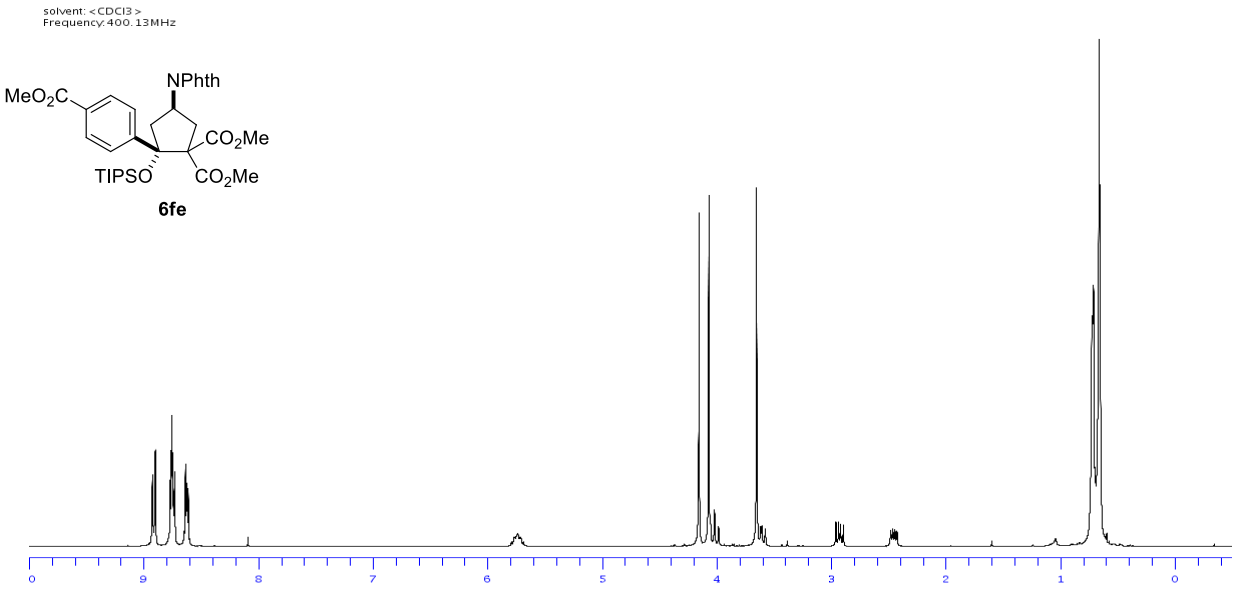
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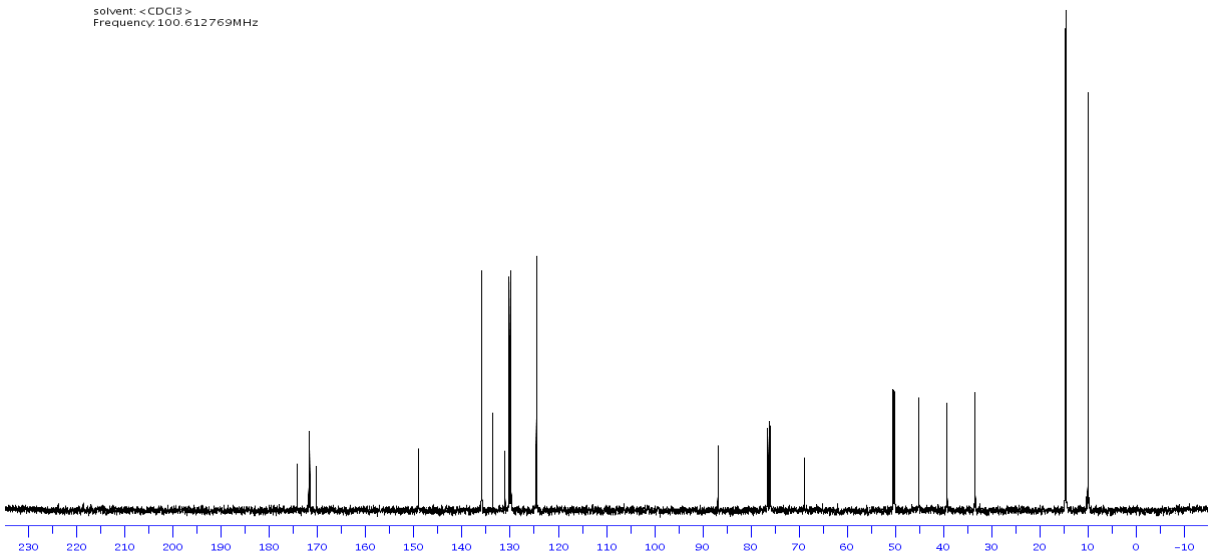
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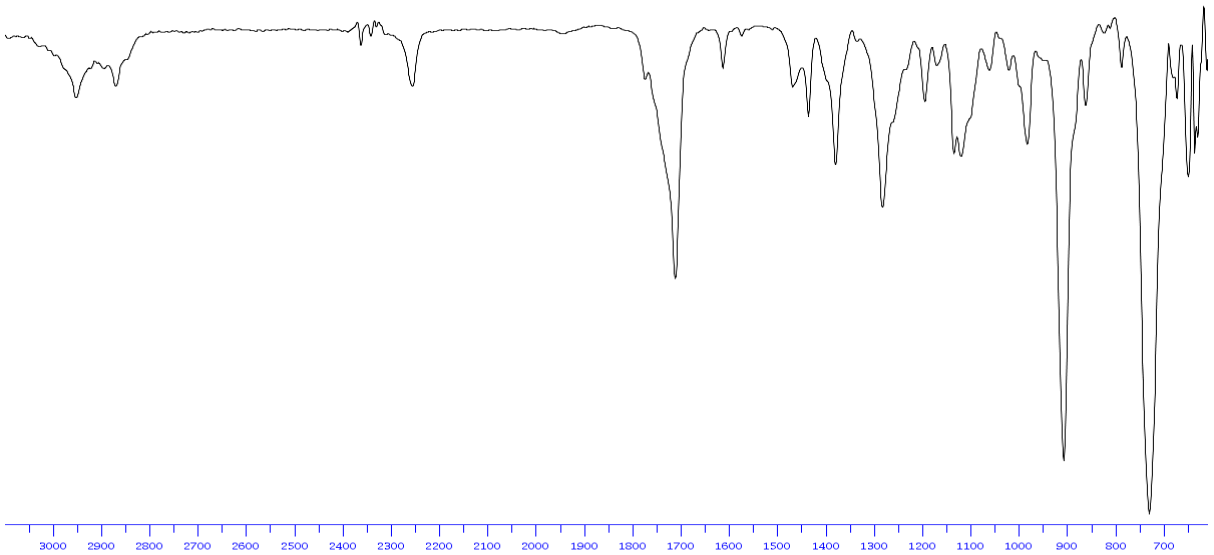

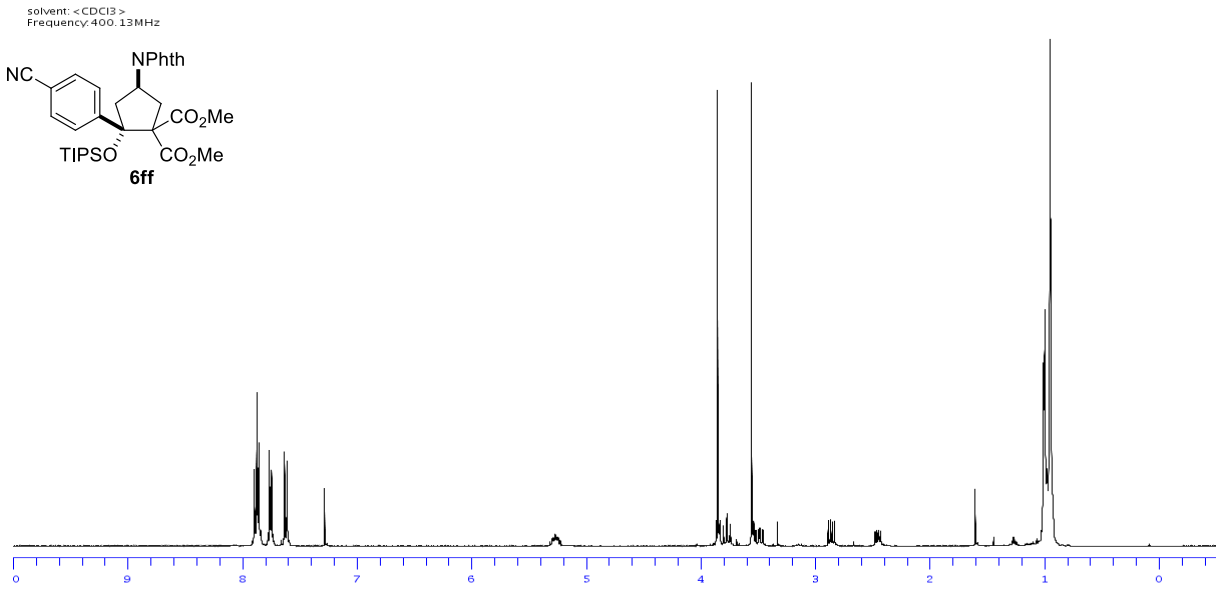
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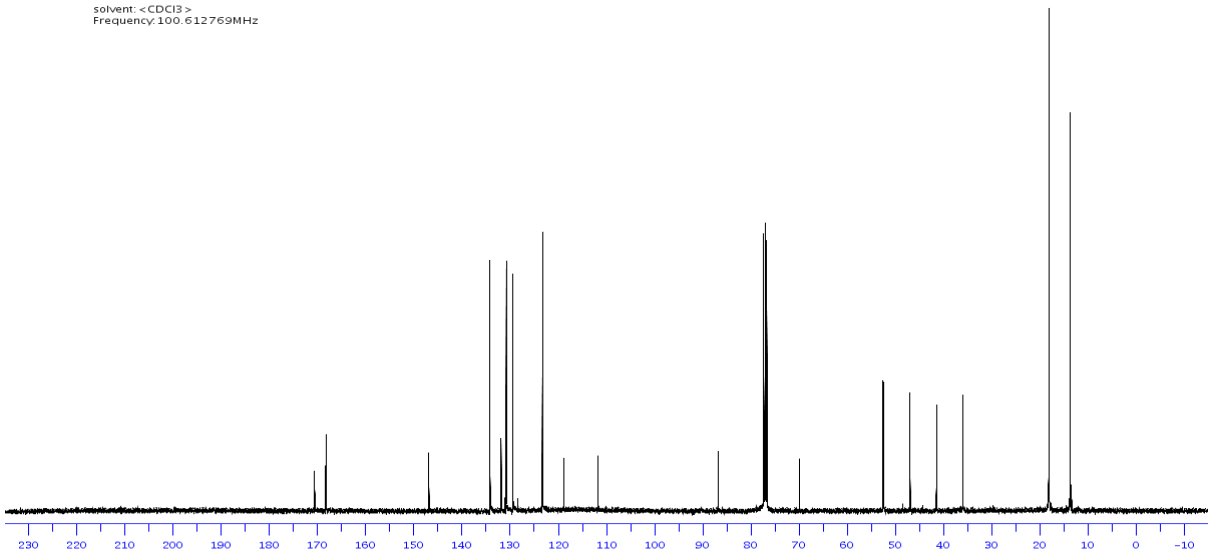
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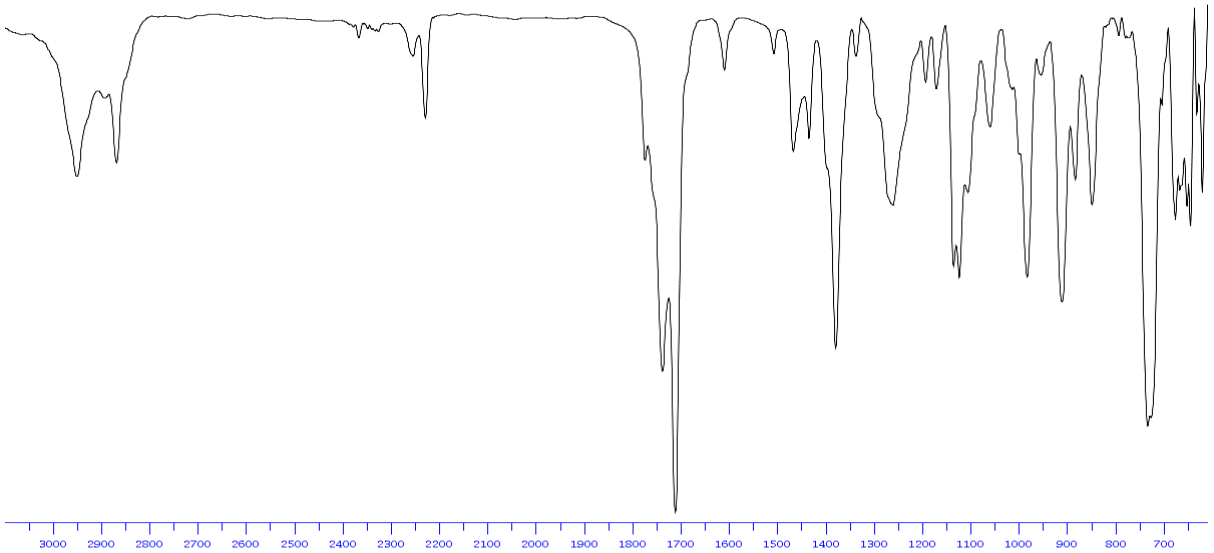

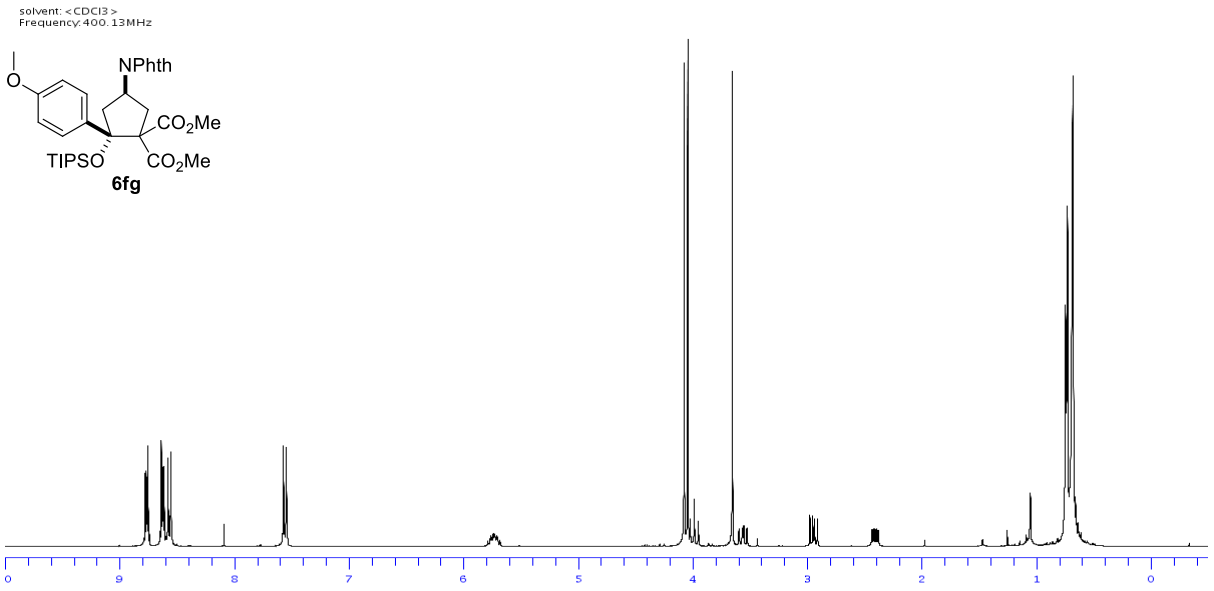
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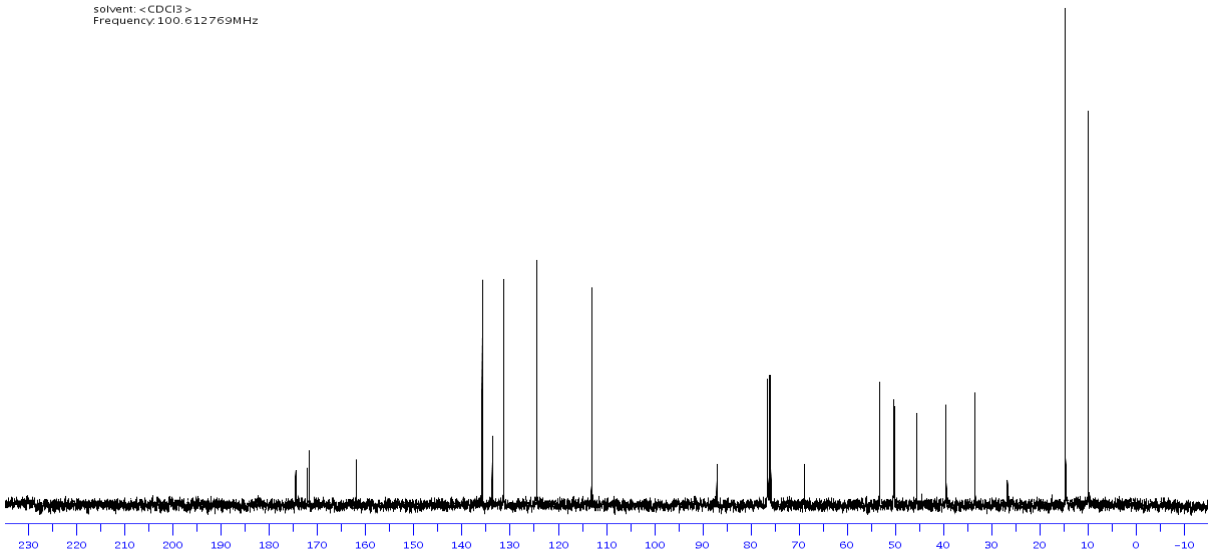
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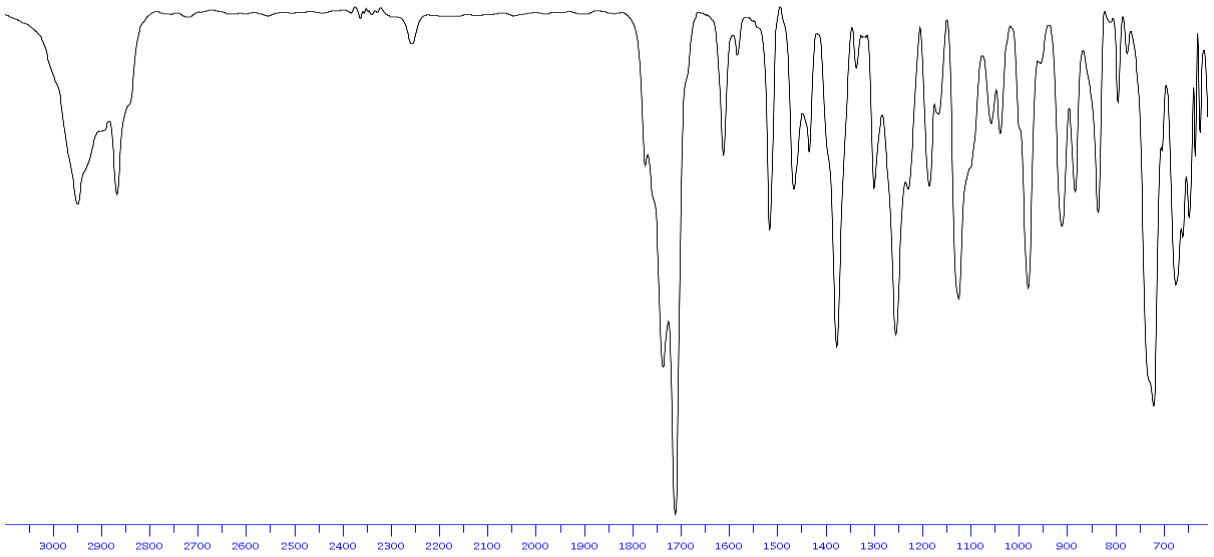

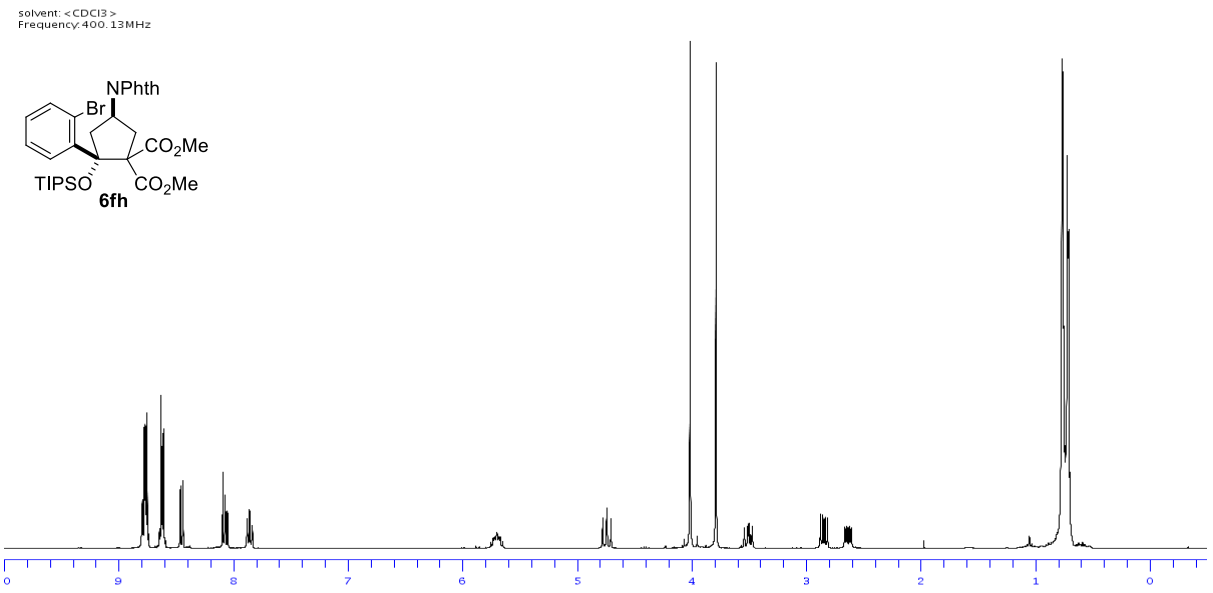
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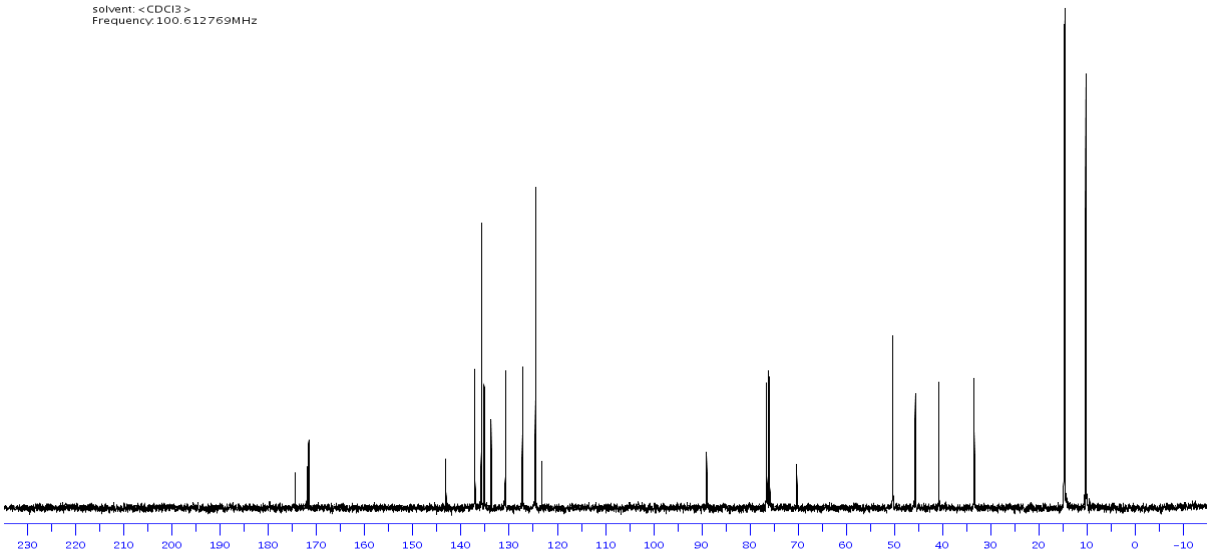
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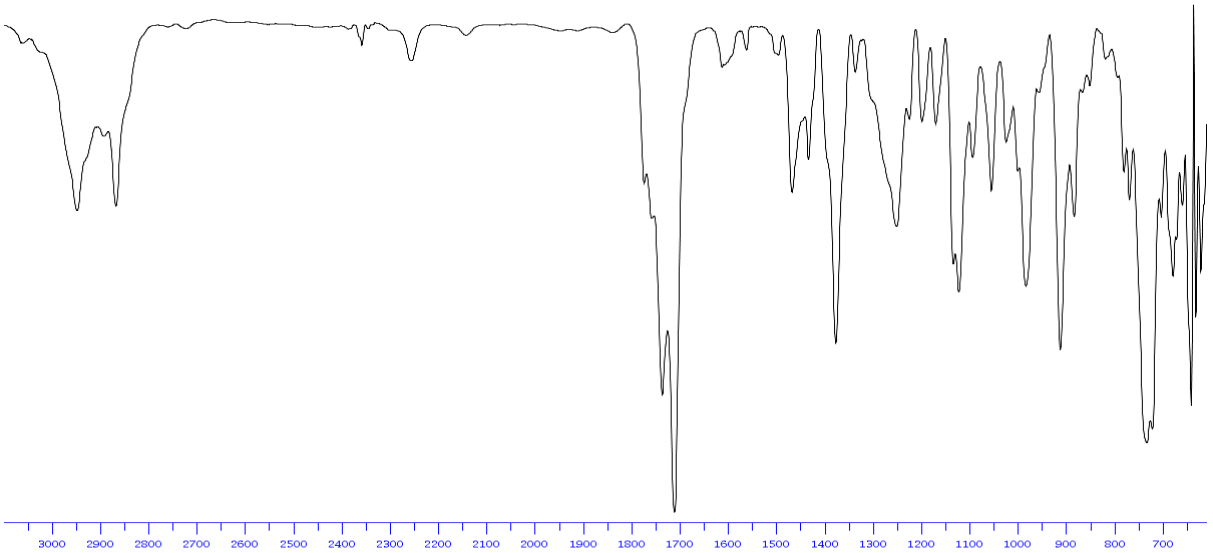

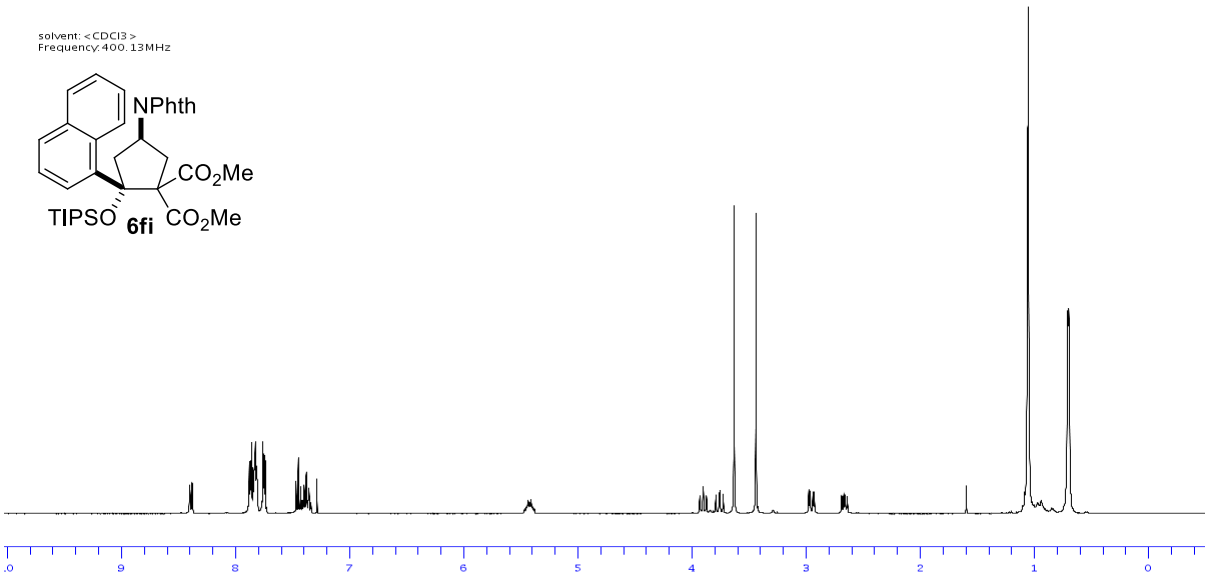
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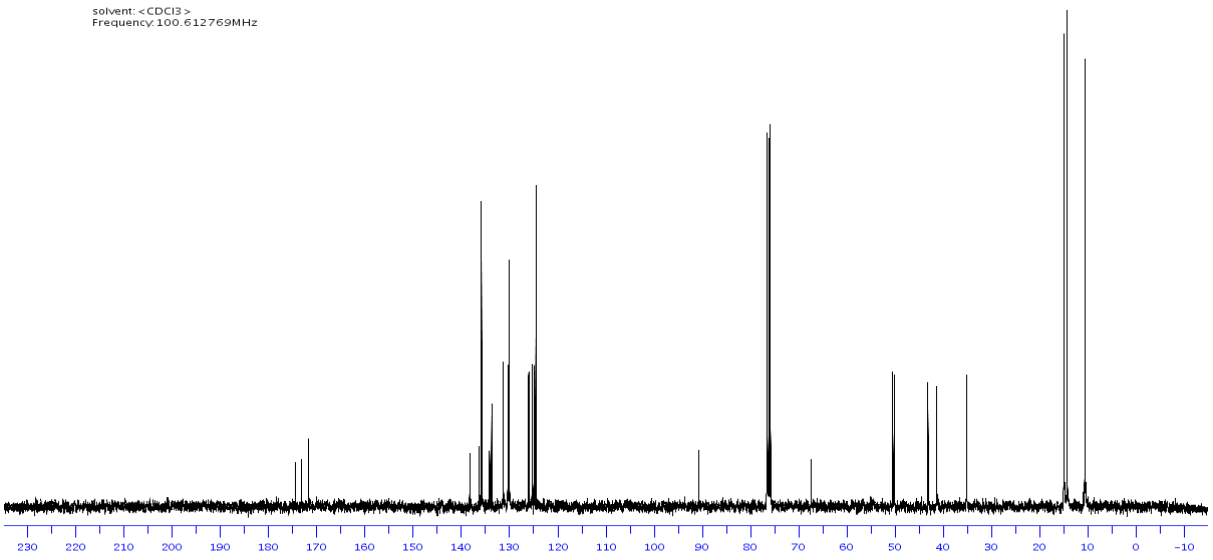
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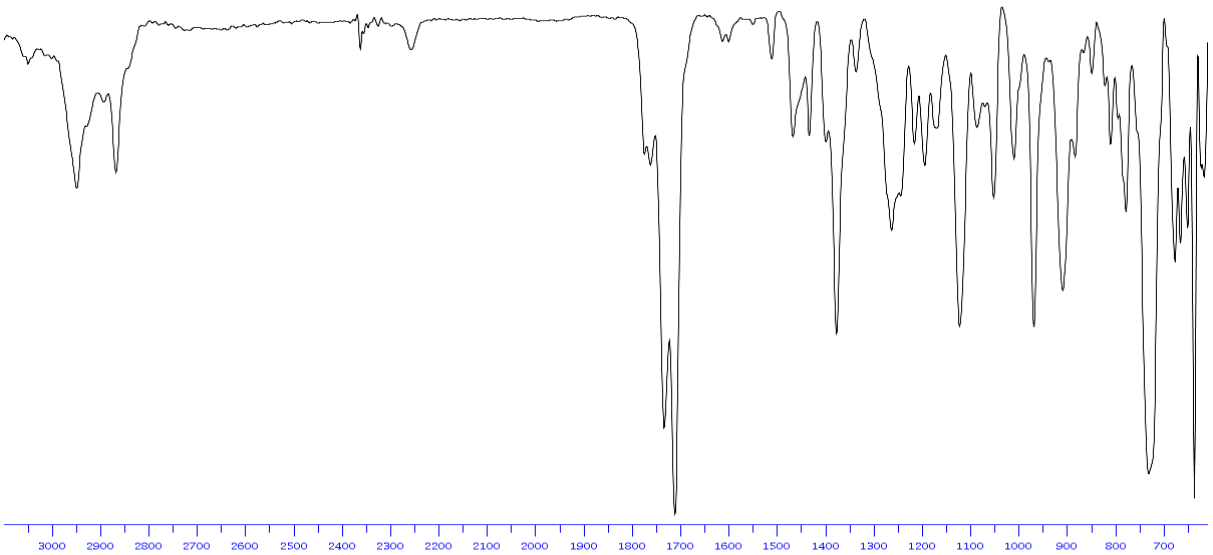

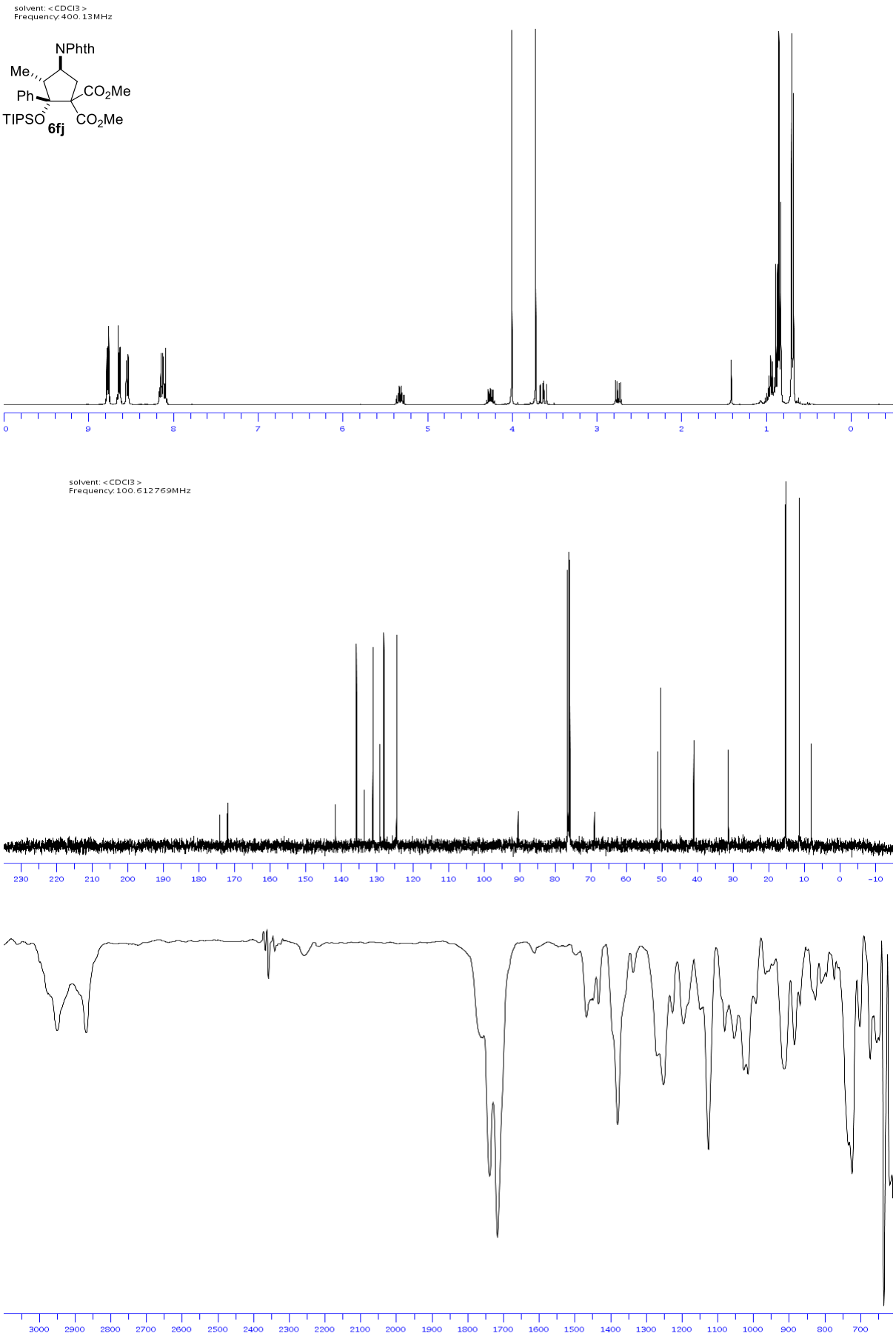
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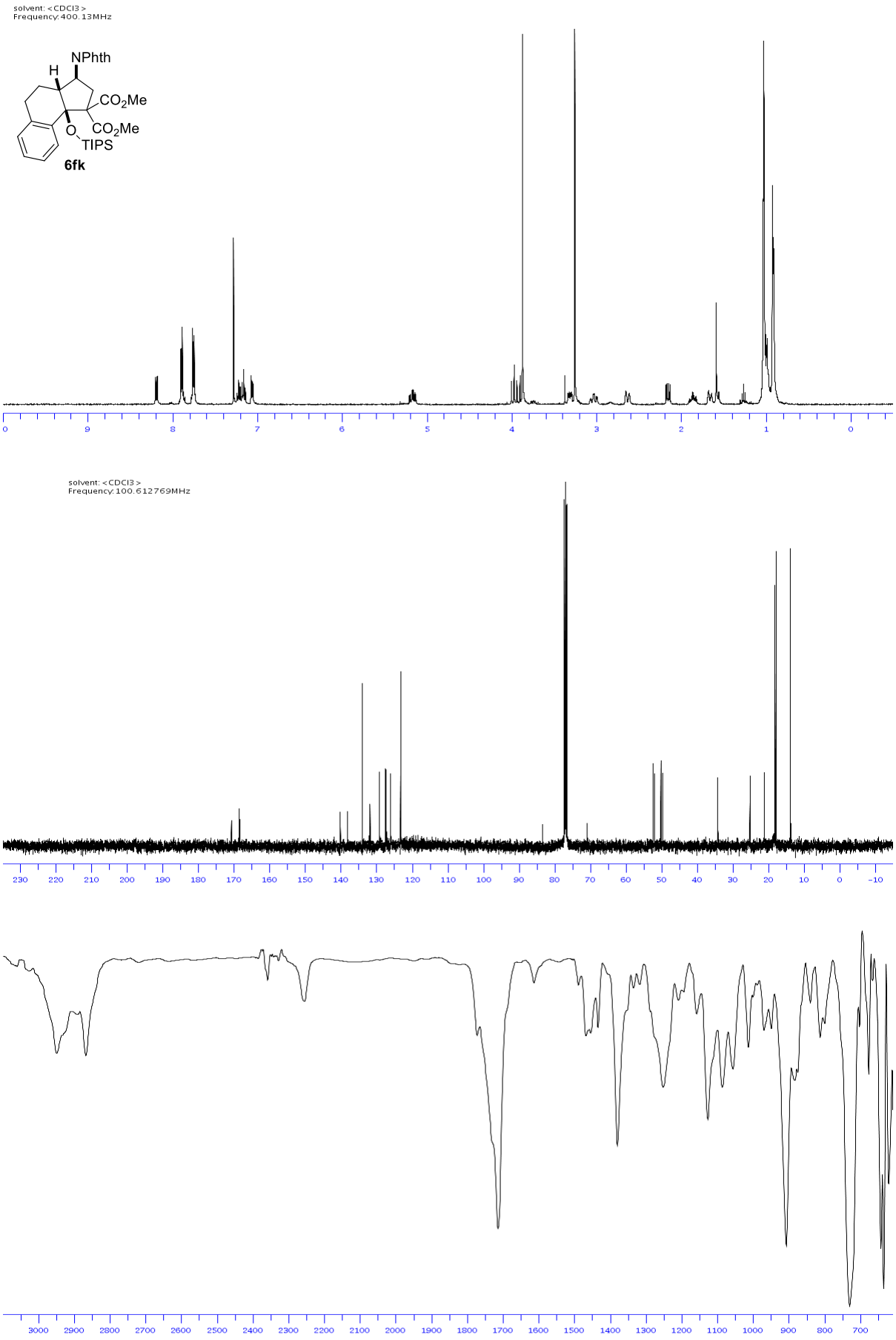
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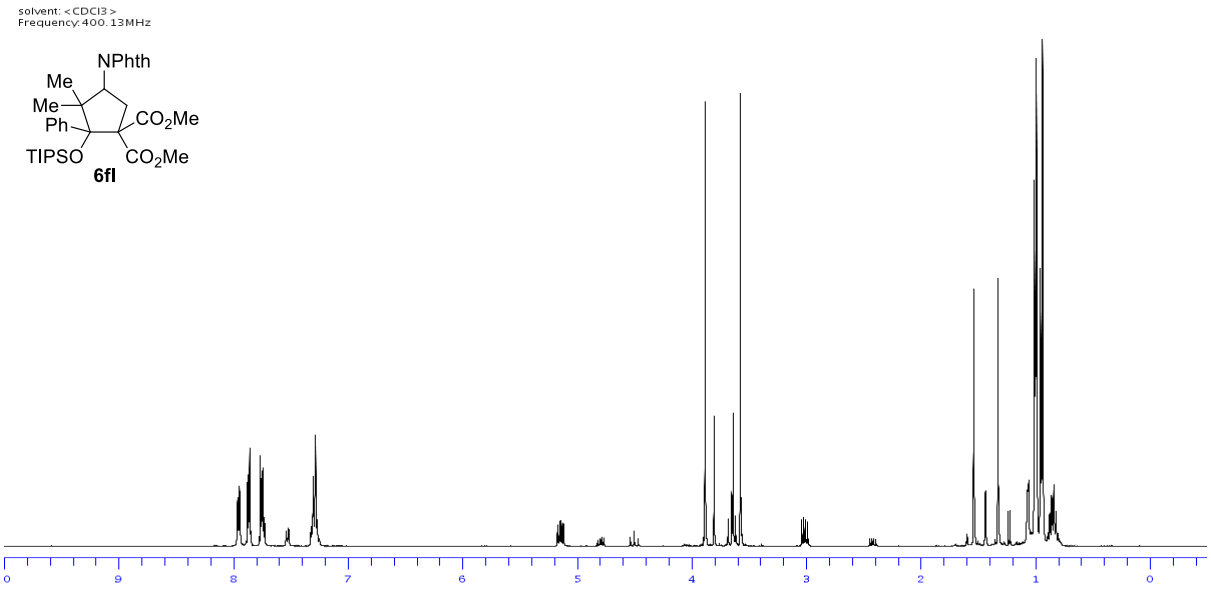
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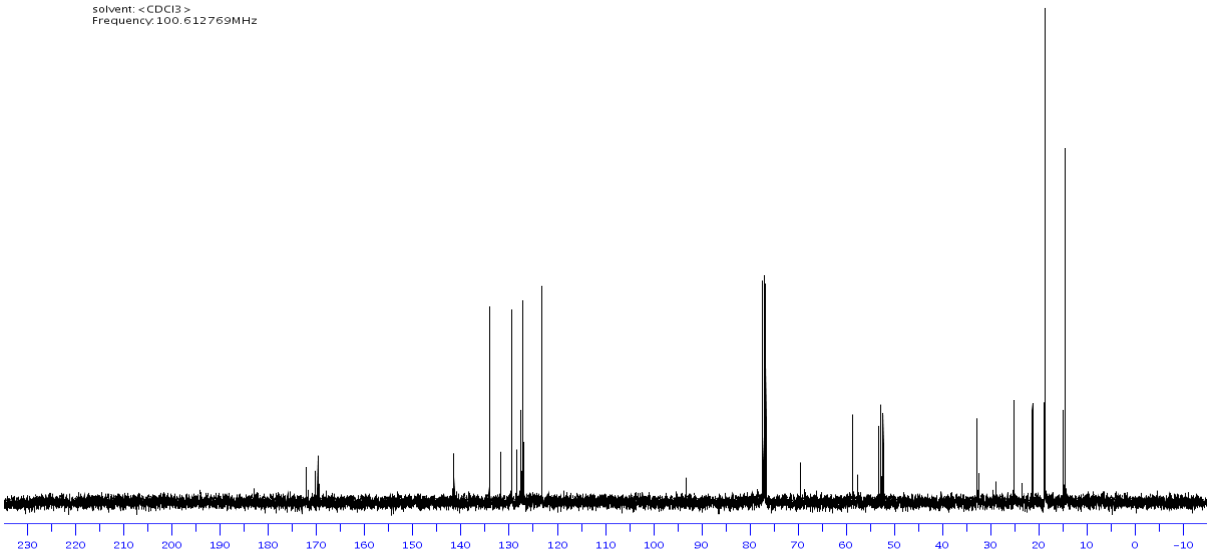
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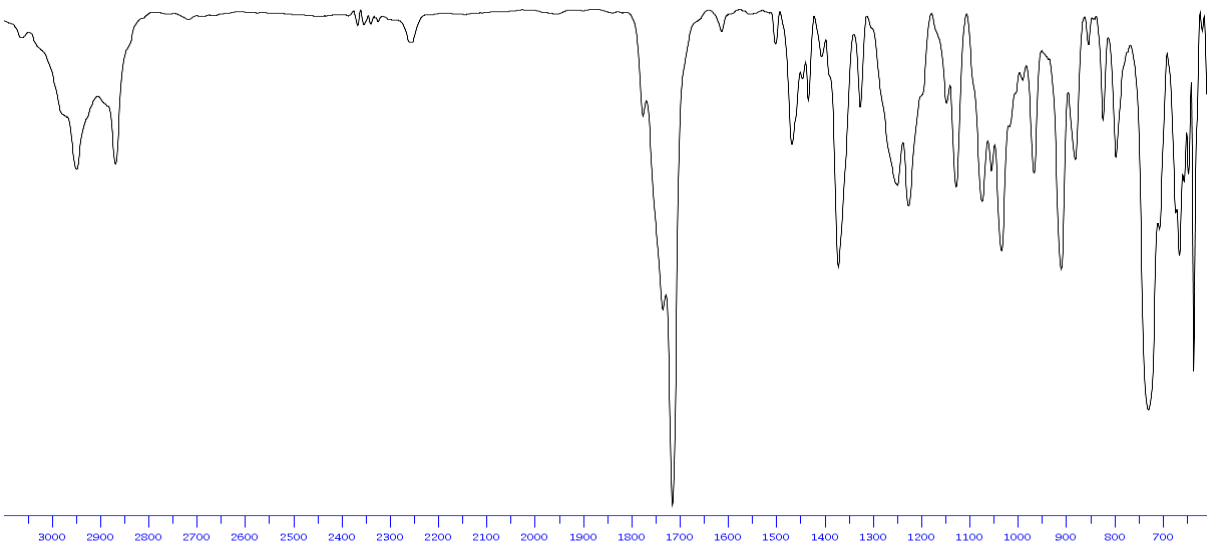

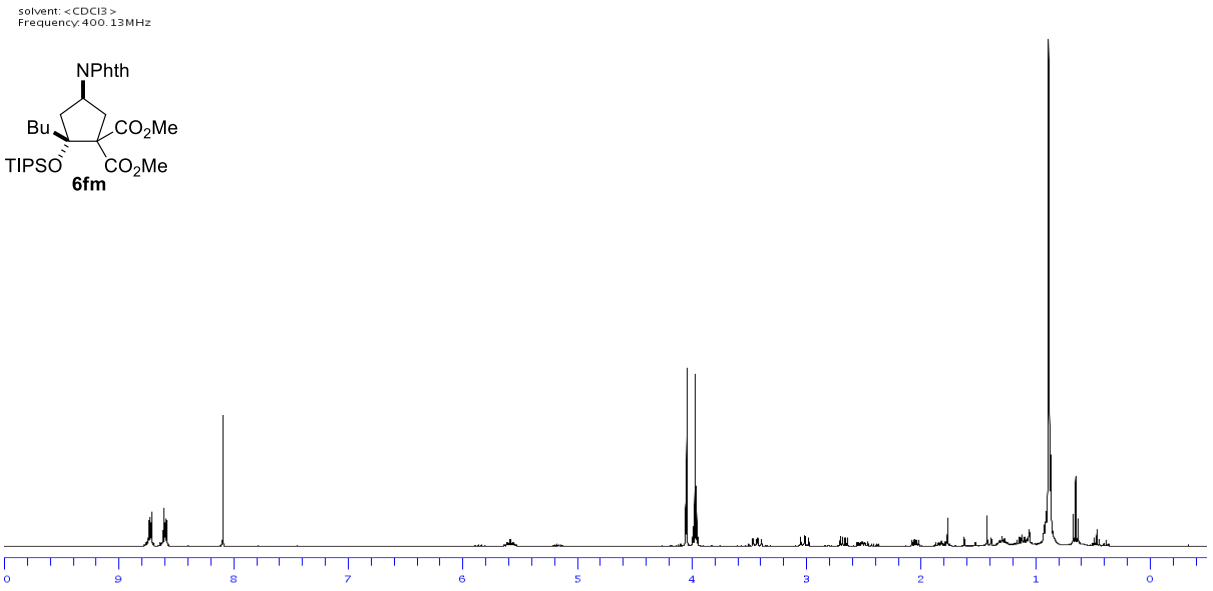
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TIPSO
CO2Me
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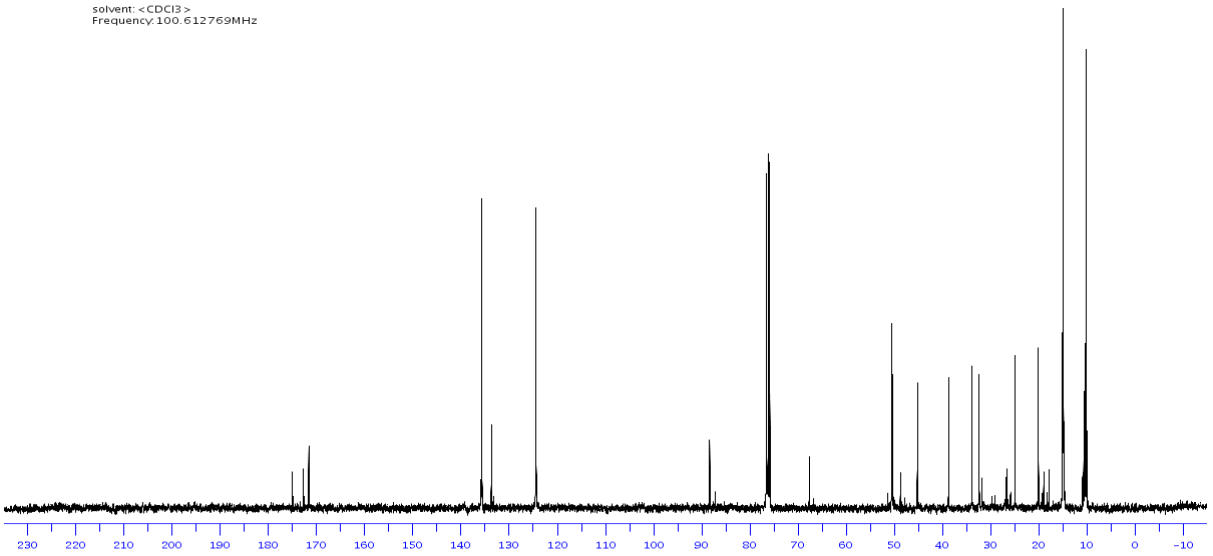
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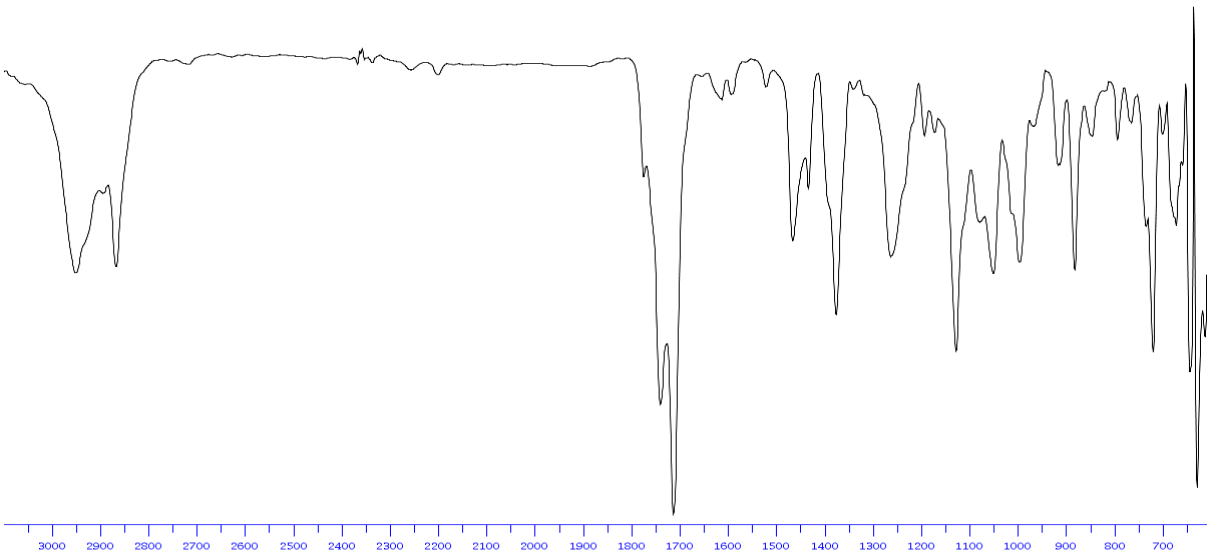
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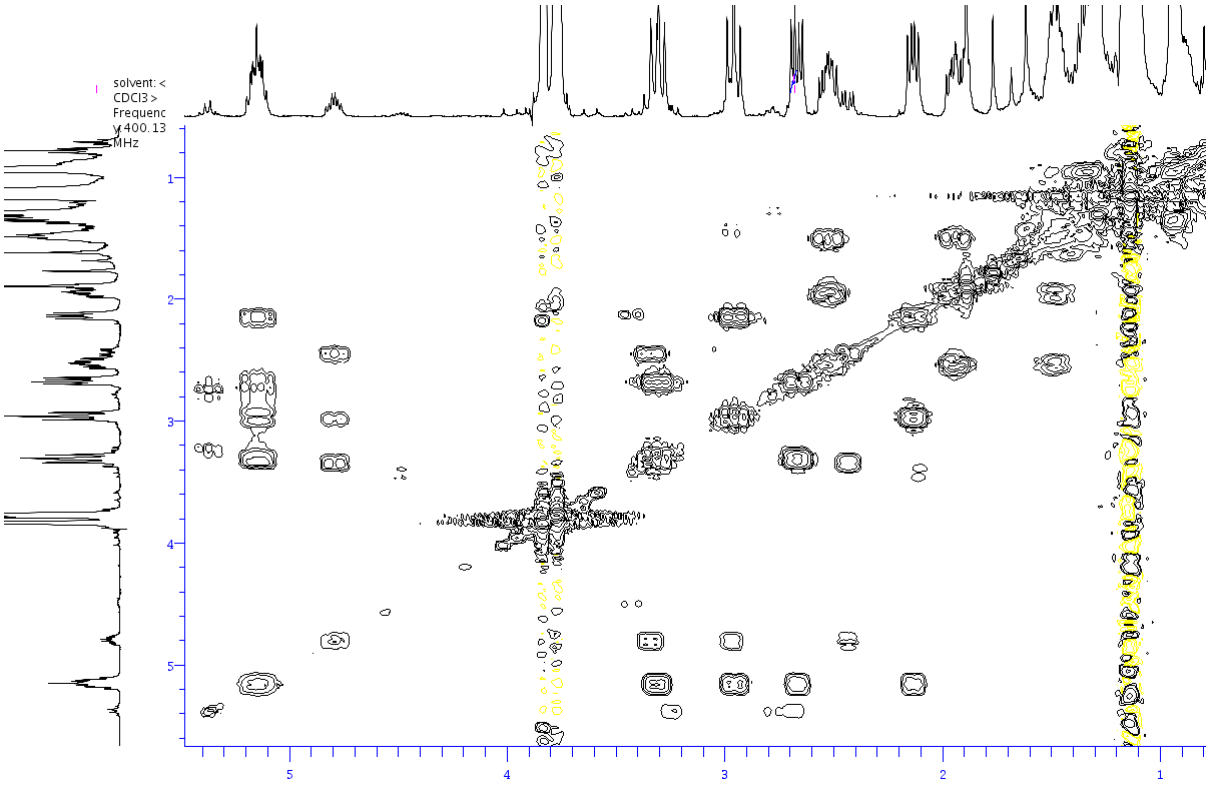
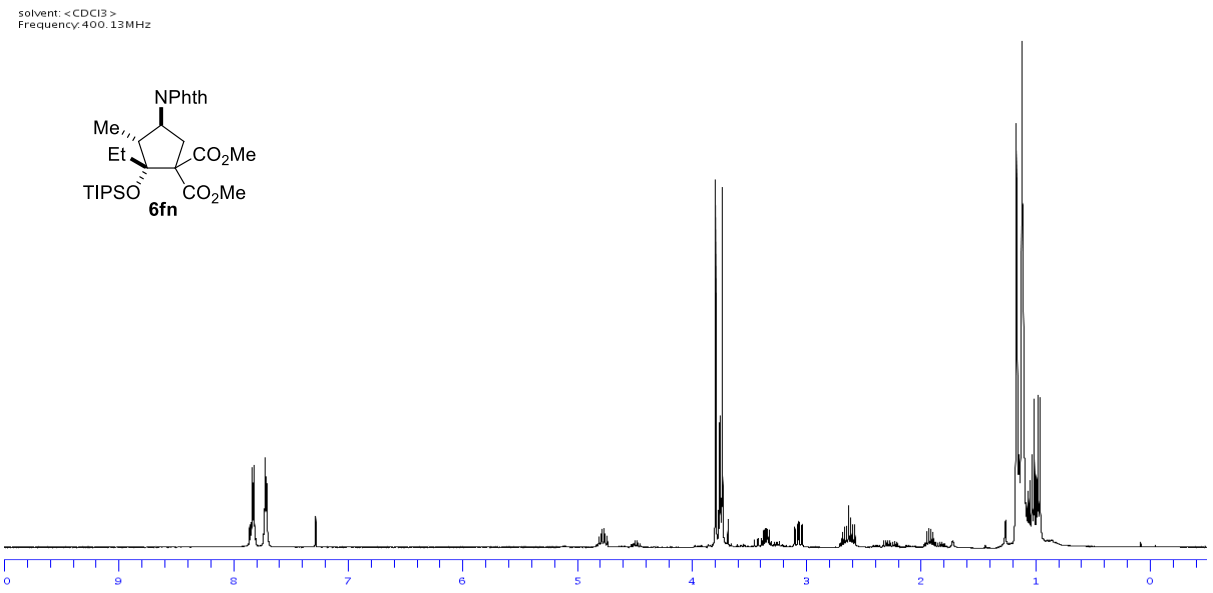


COSY 6fm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NPhth
Me
Et
CO2Me
TIPSO
CO2Me
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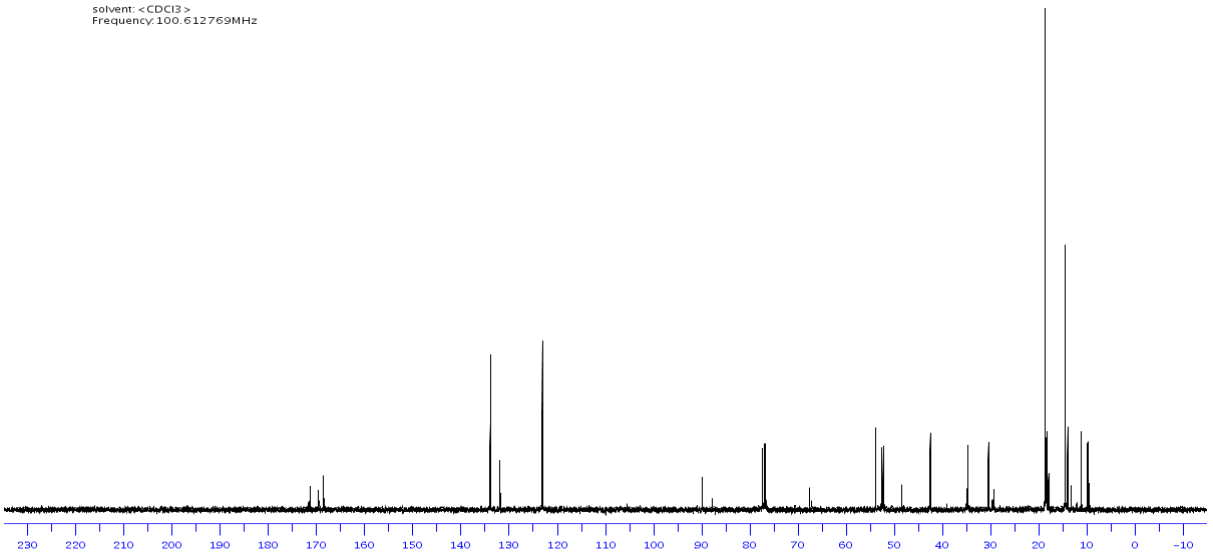
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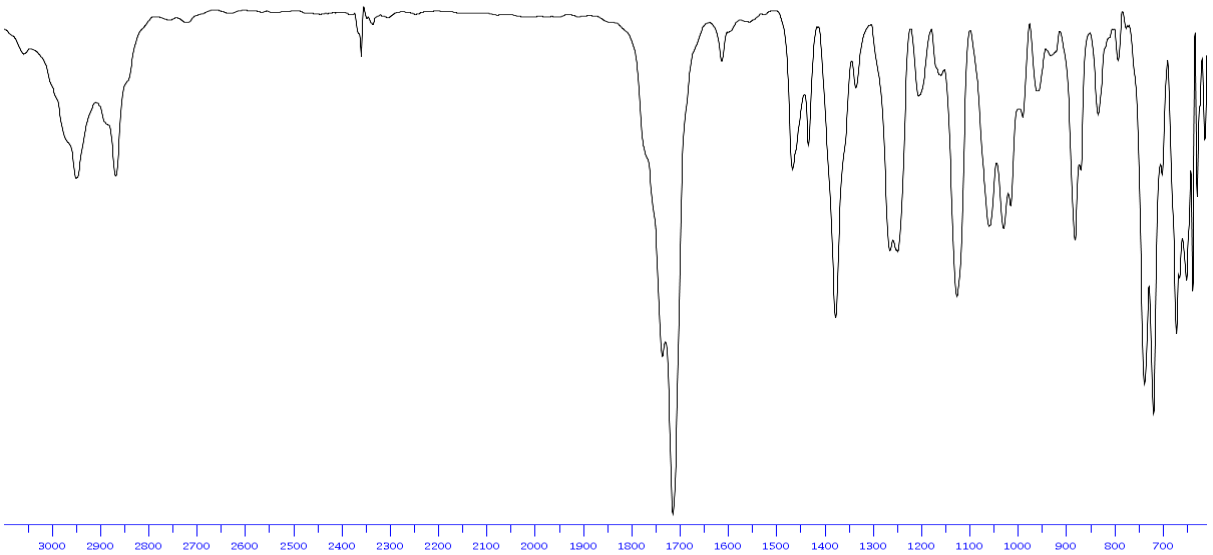

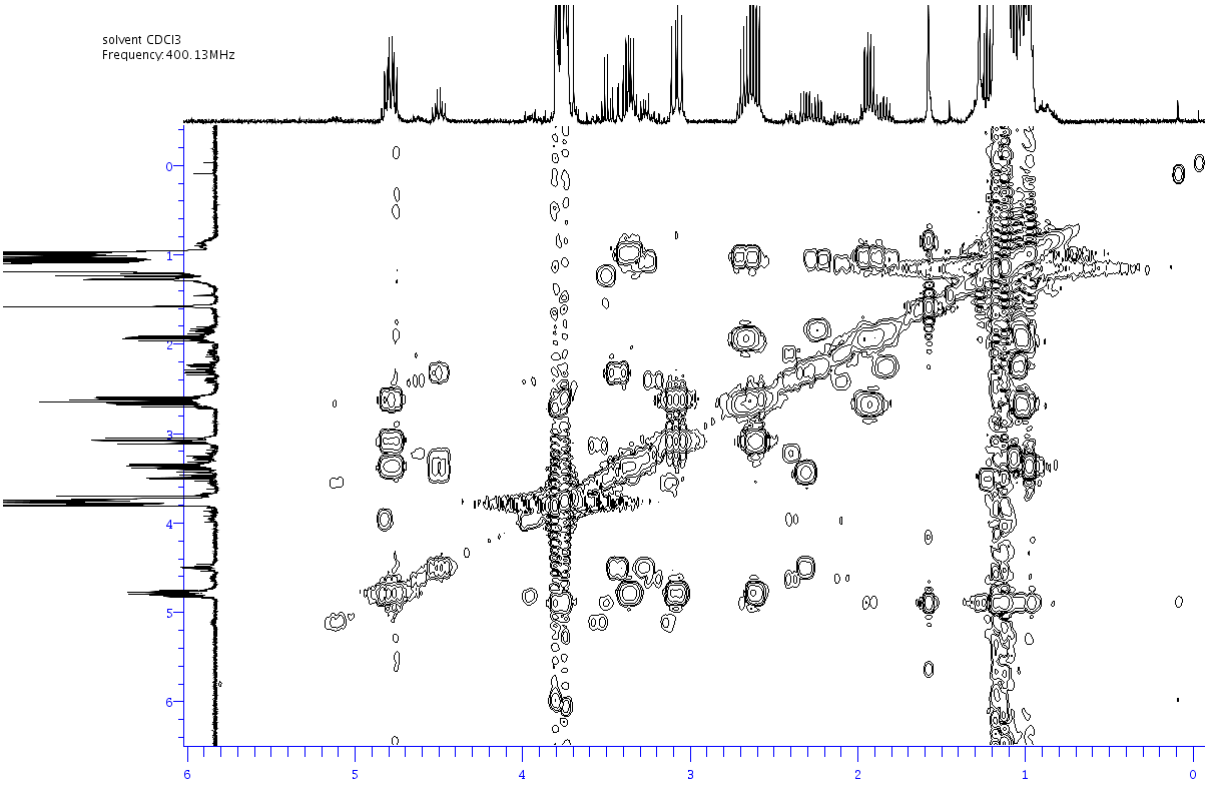

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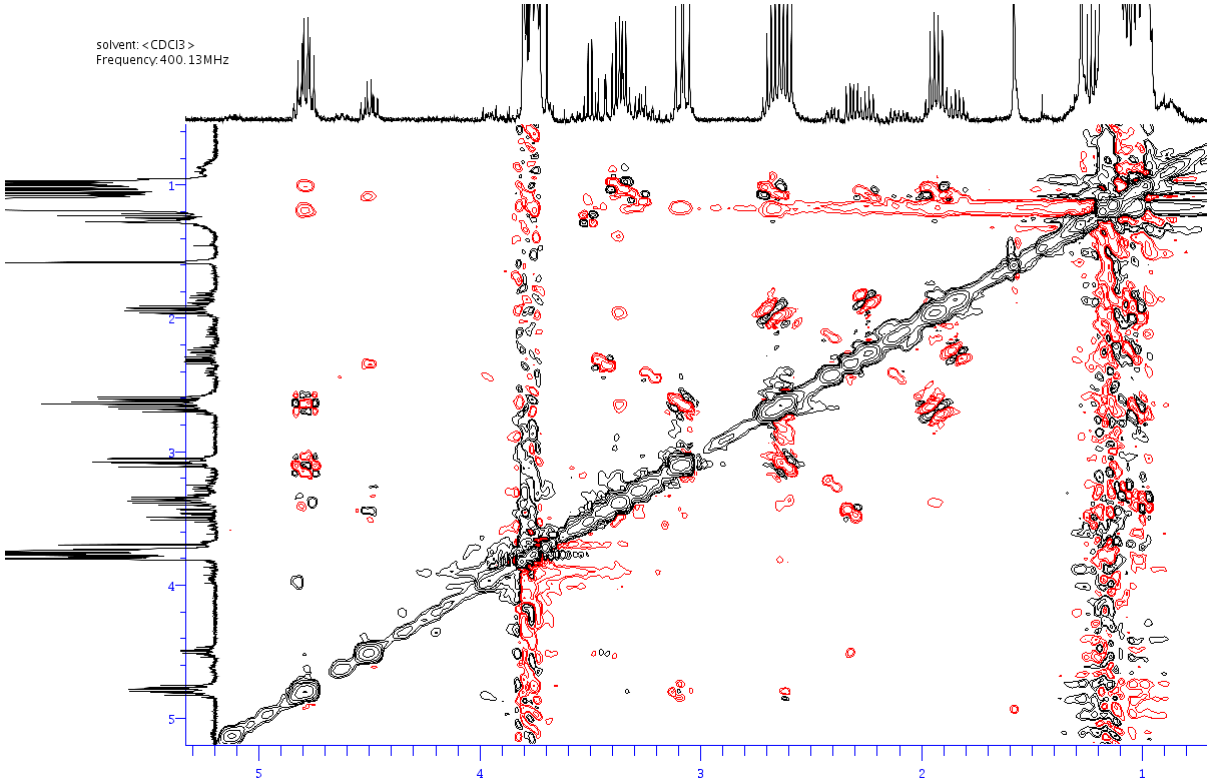
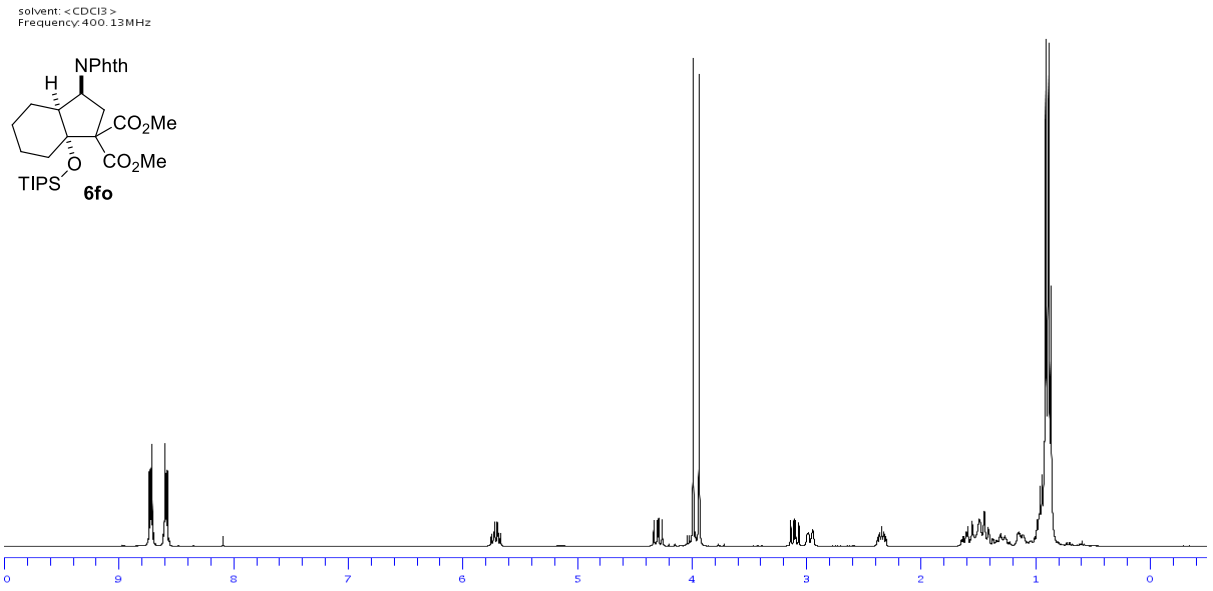


ROESY 6fn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H
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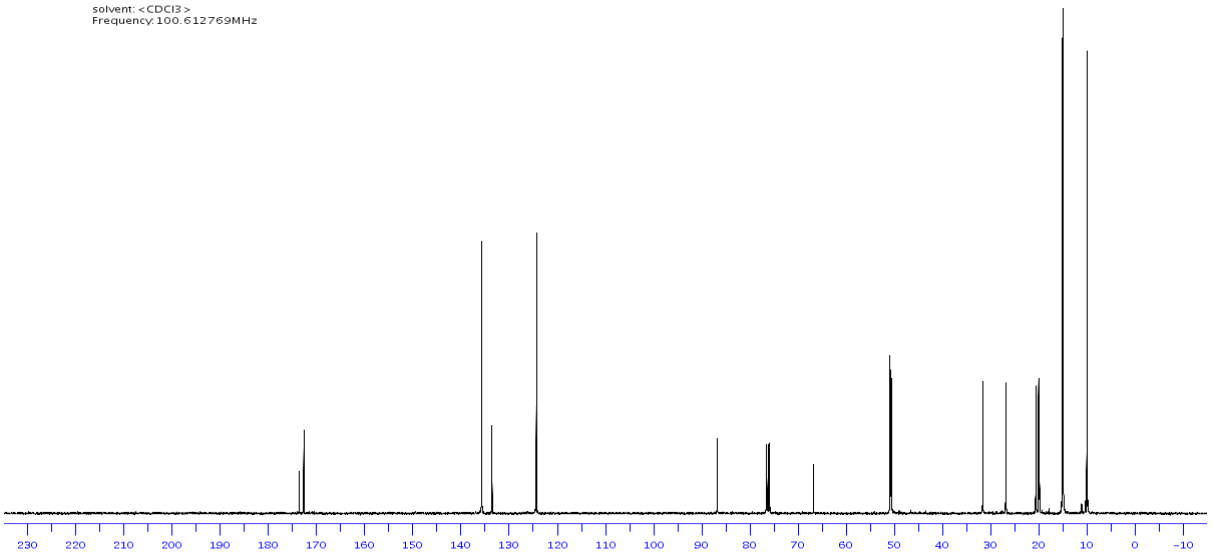
CO2Me
O
TIPS
6fo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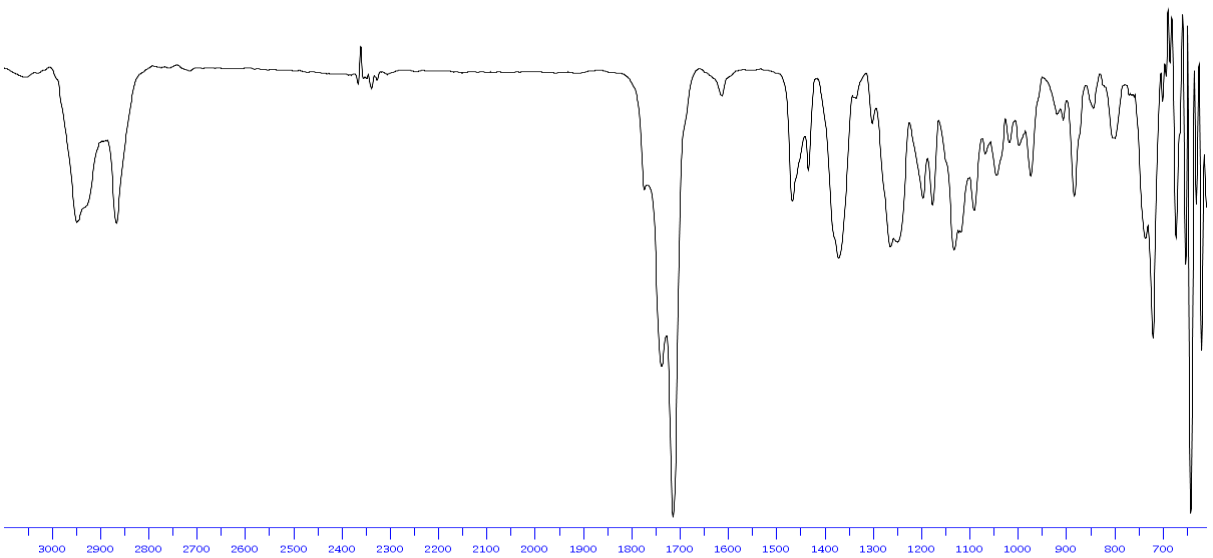

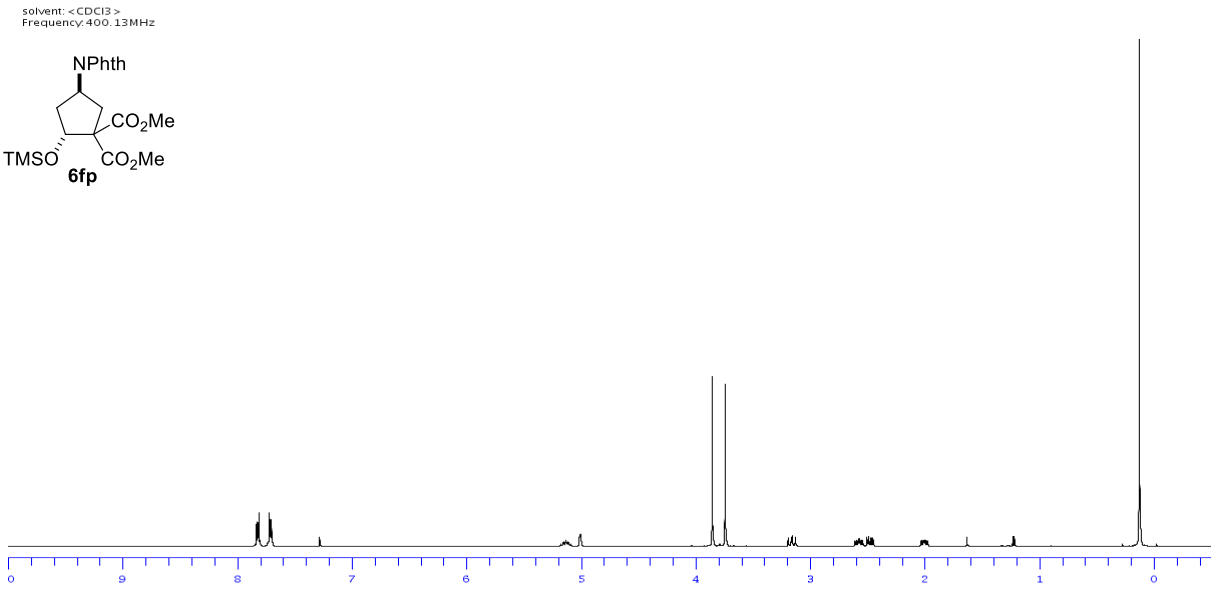
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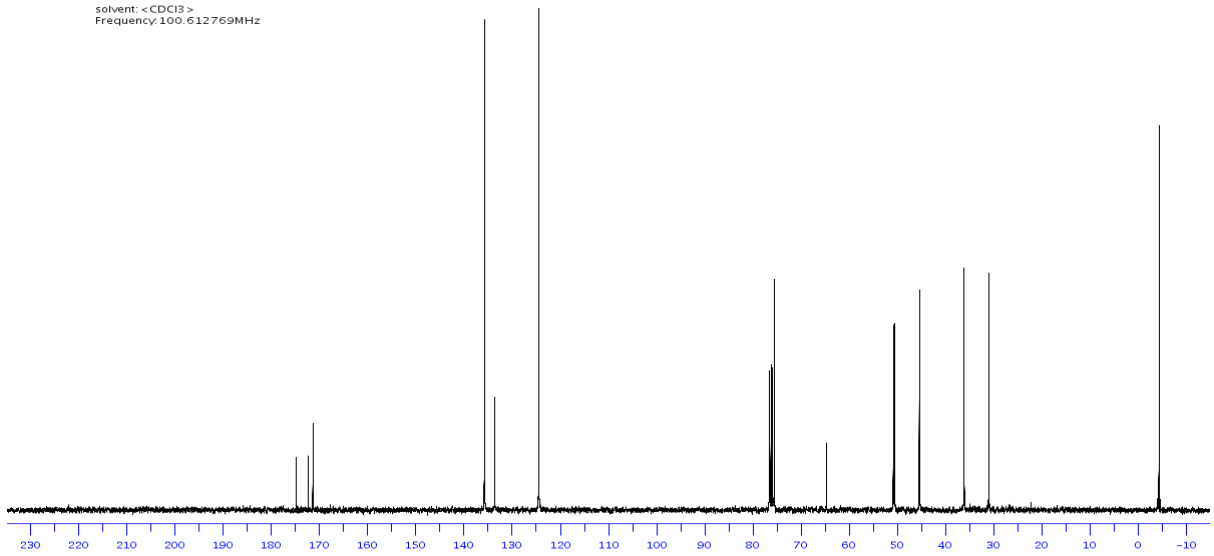
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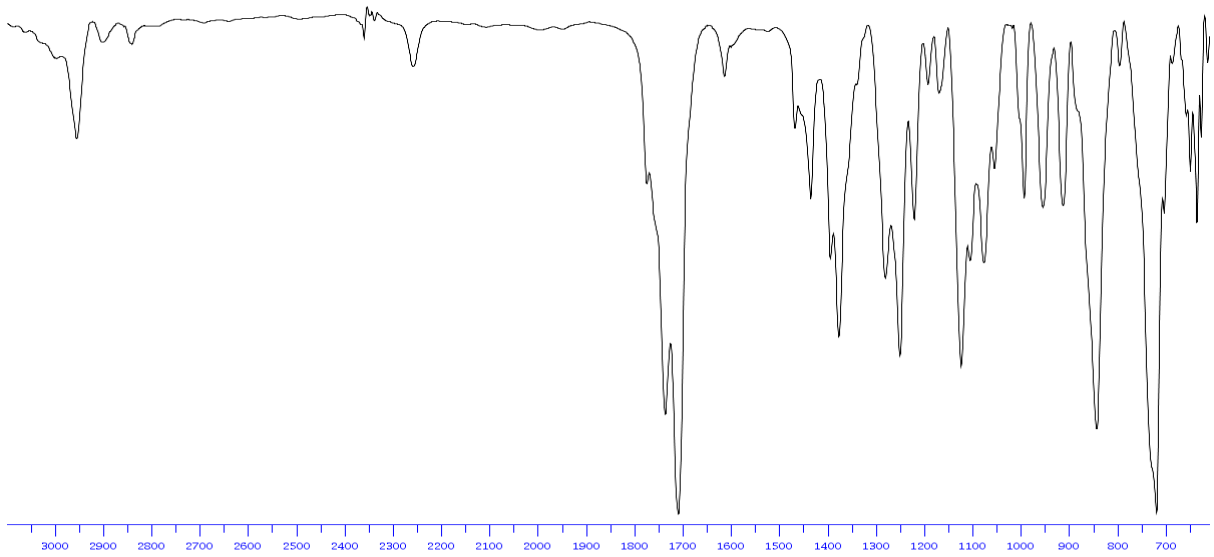
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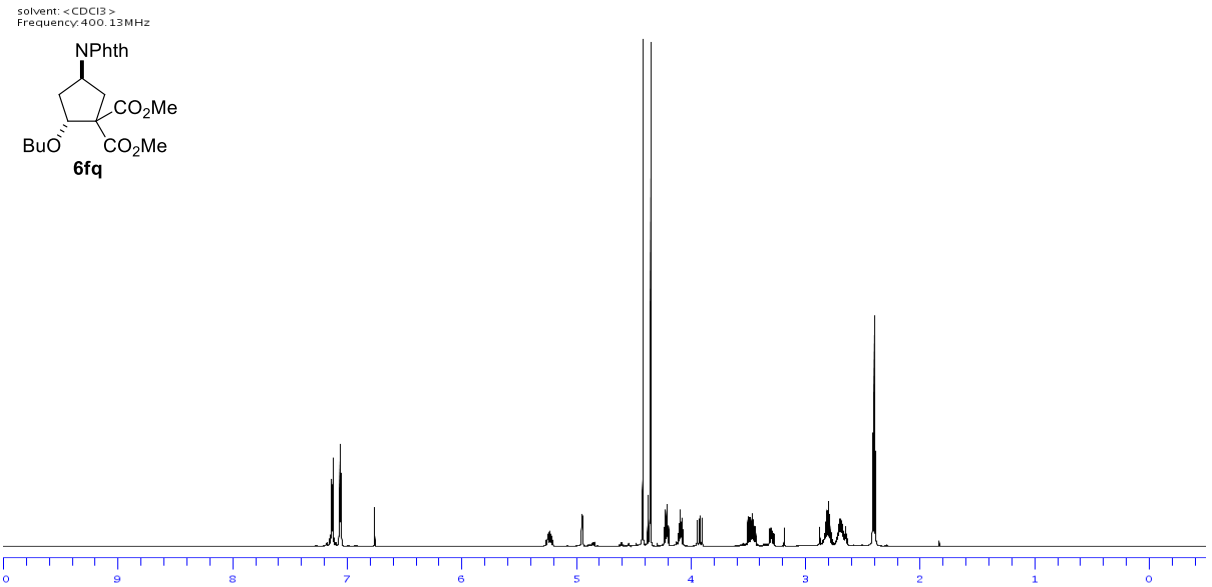
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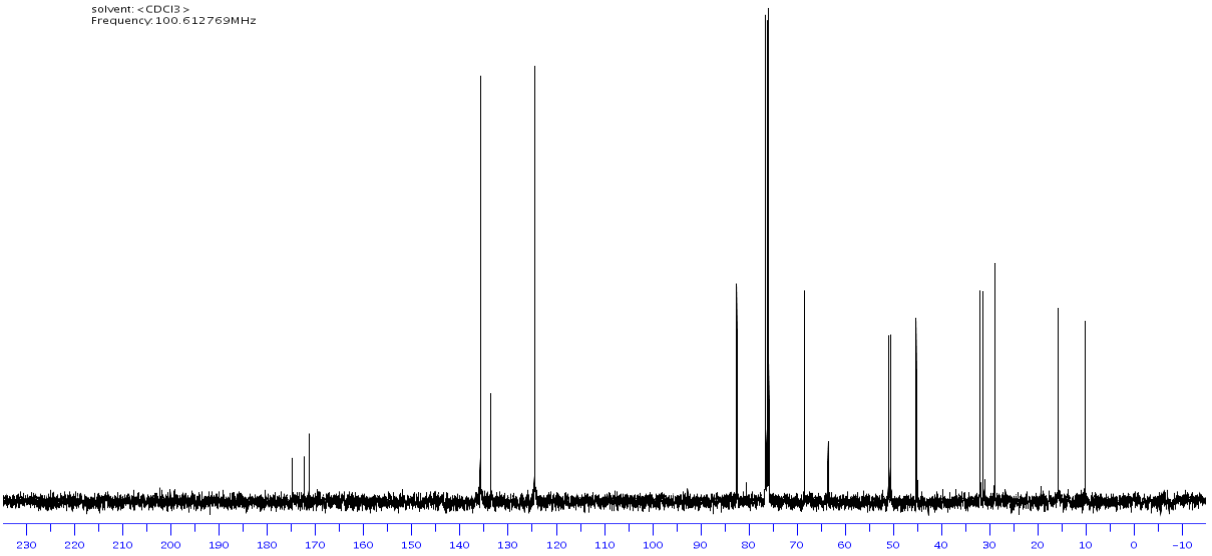
CO2Me
6fq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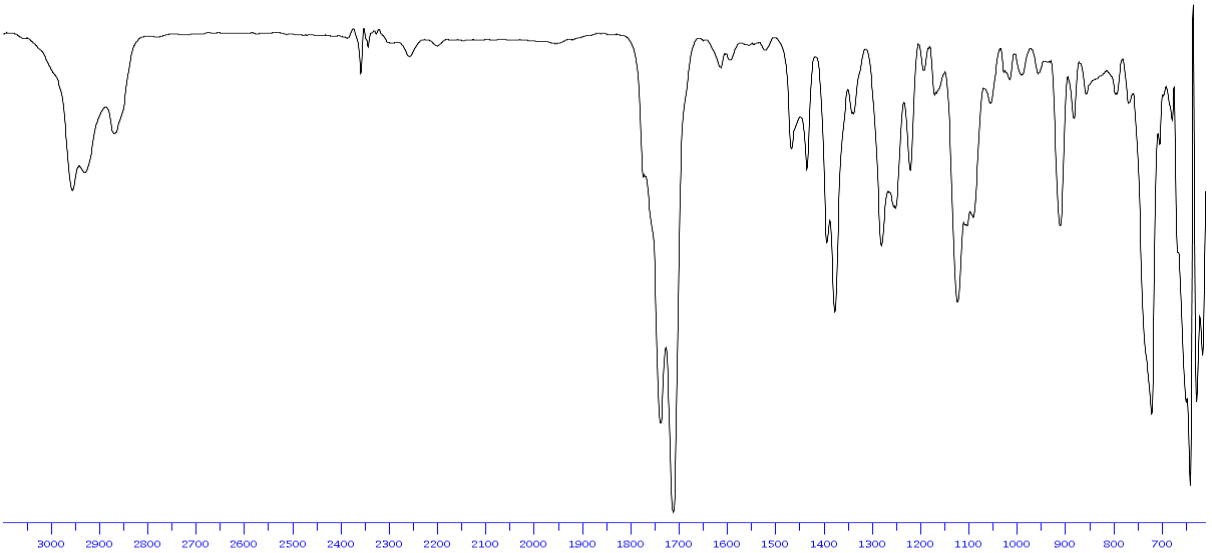

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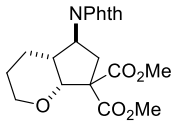

6fr-trans

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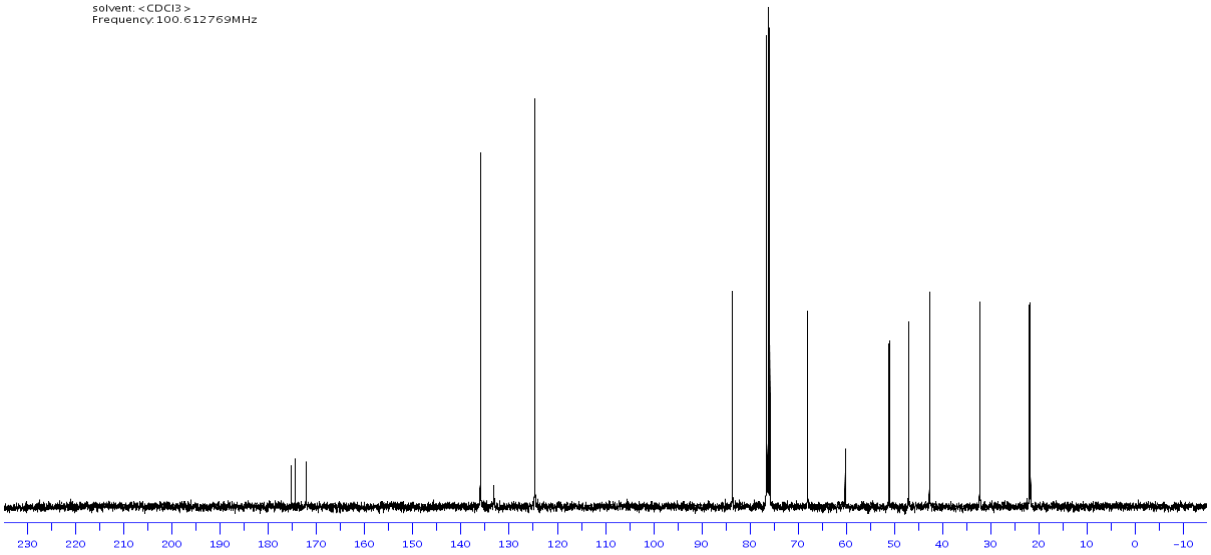

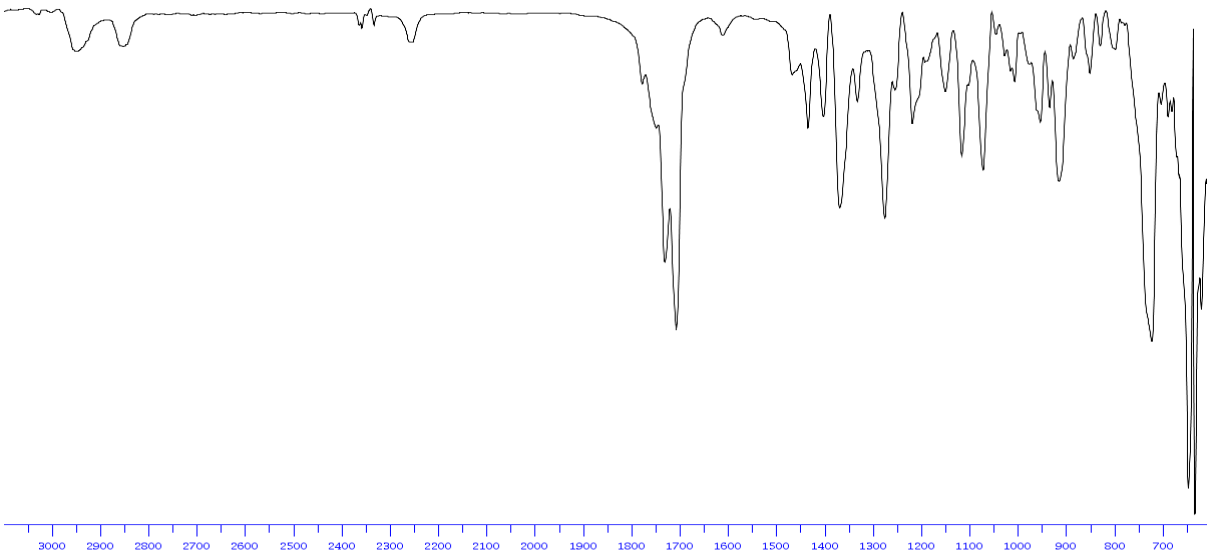

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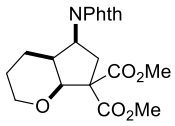

6fr-cis

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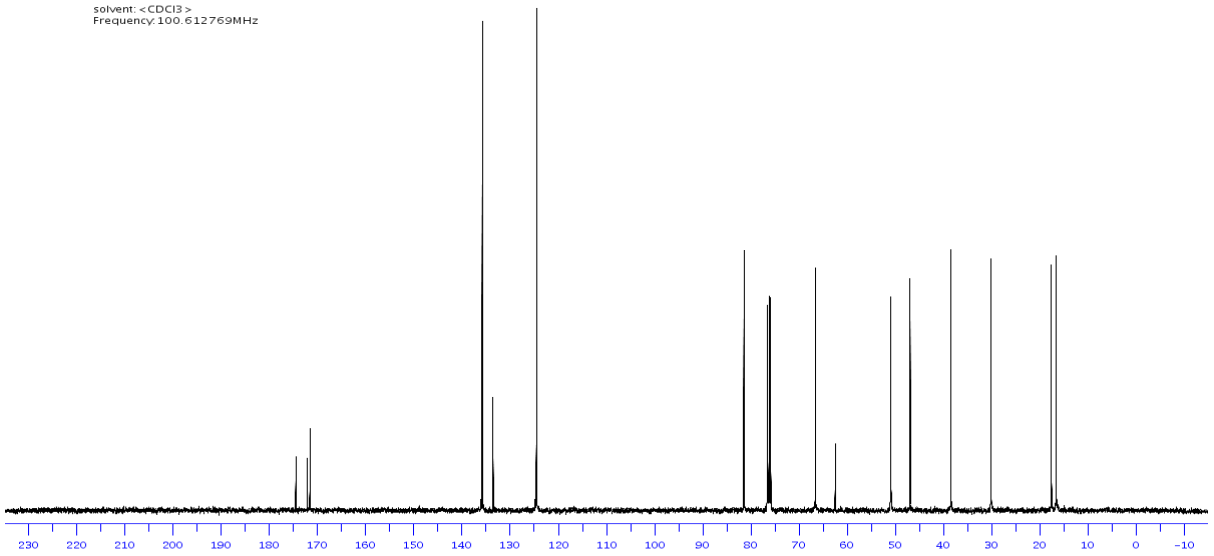

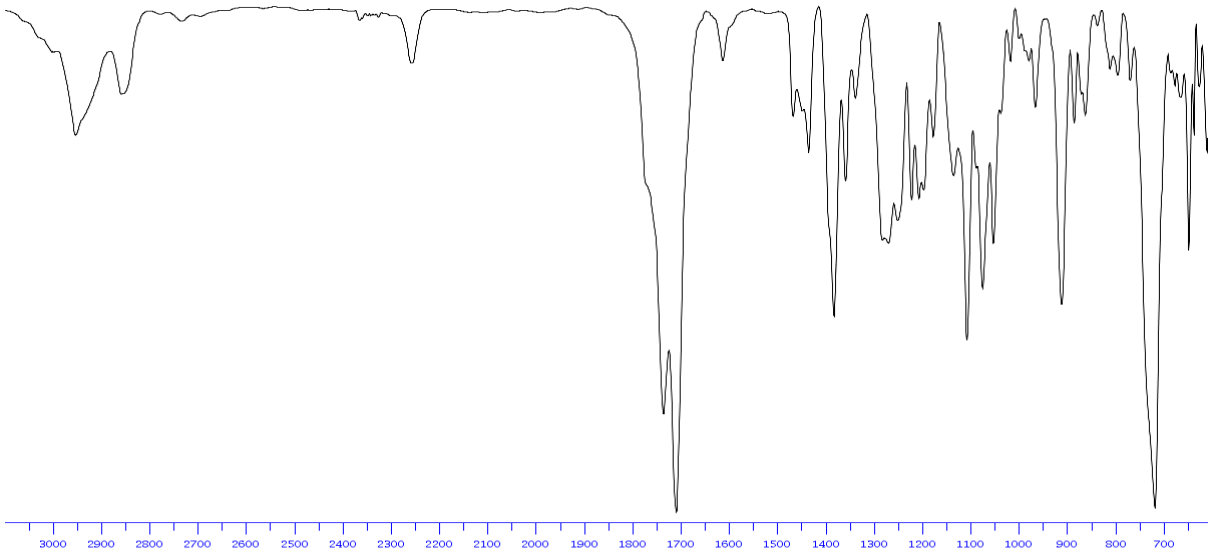

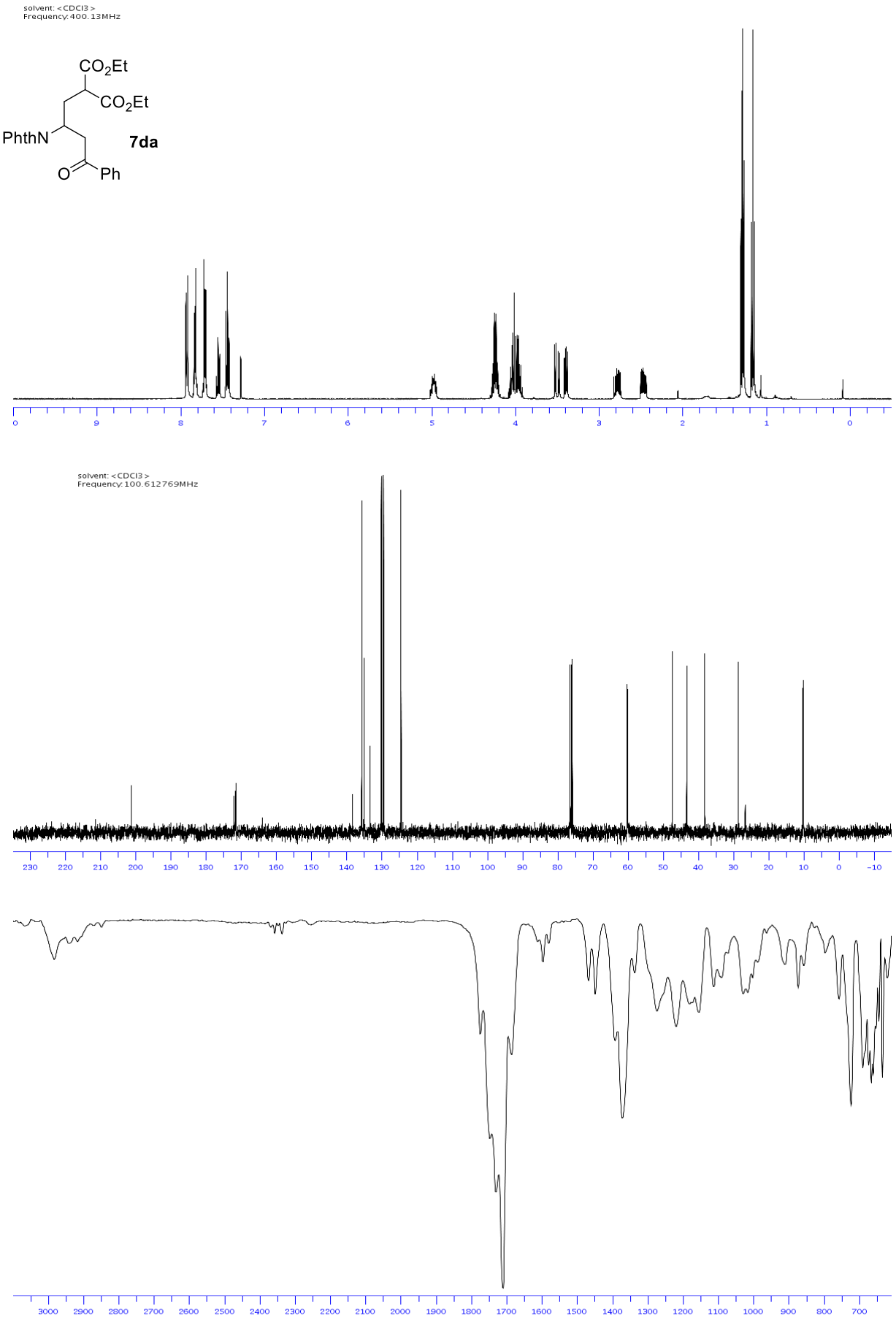
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CO2Et
PhthN
7da
O
Ph
0 9 8 7 6 5 4 3 2 1 0
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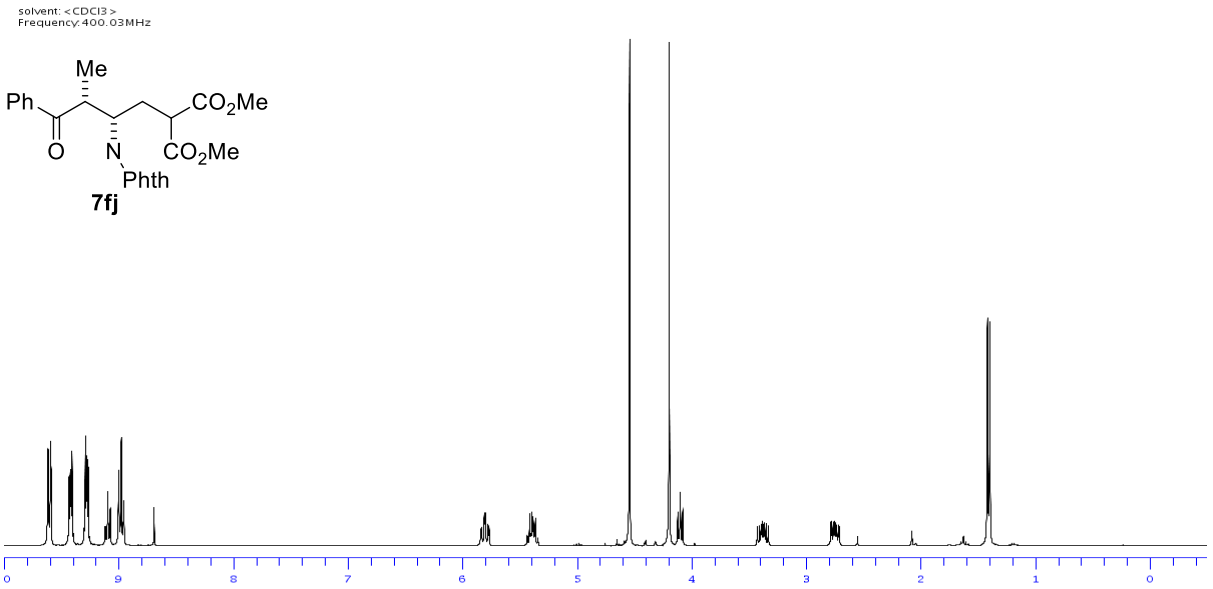
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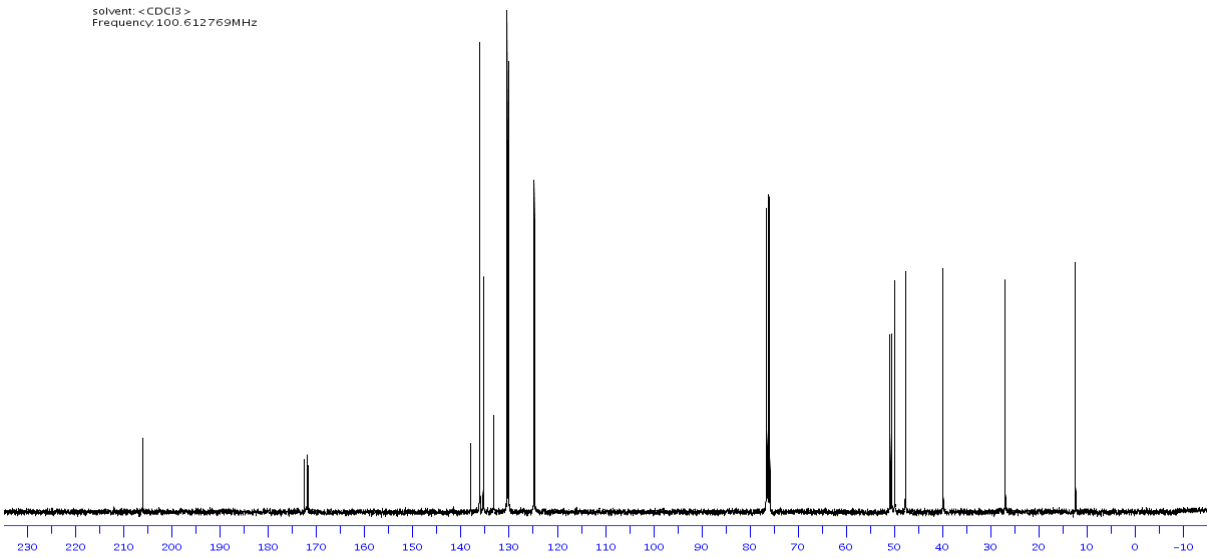
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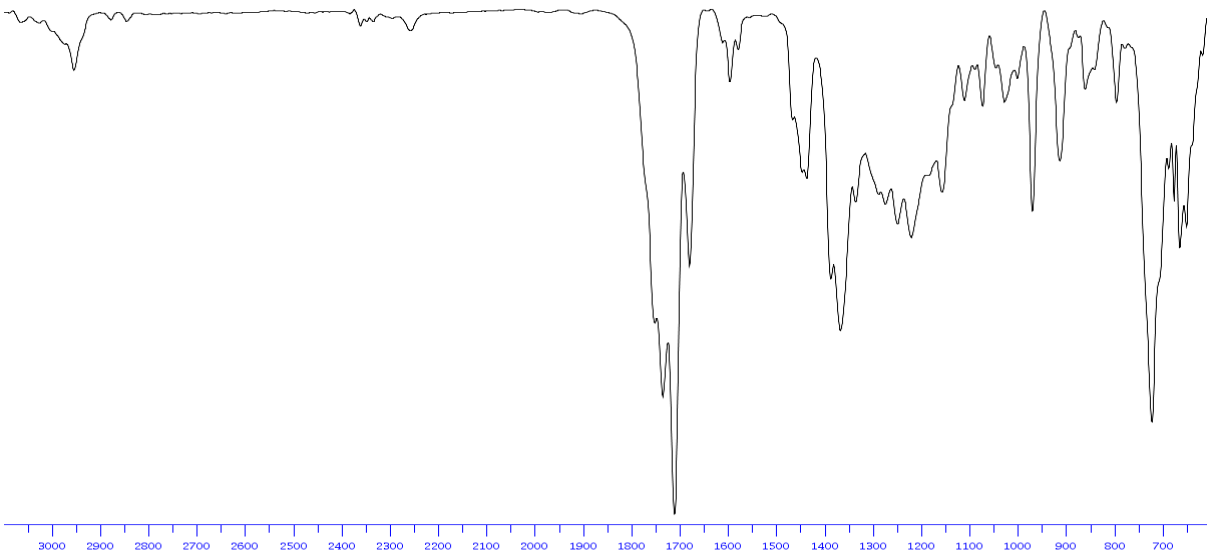

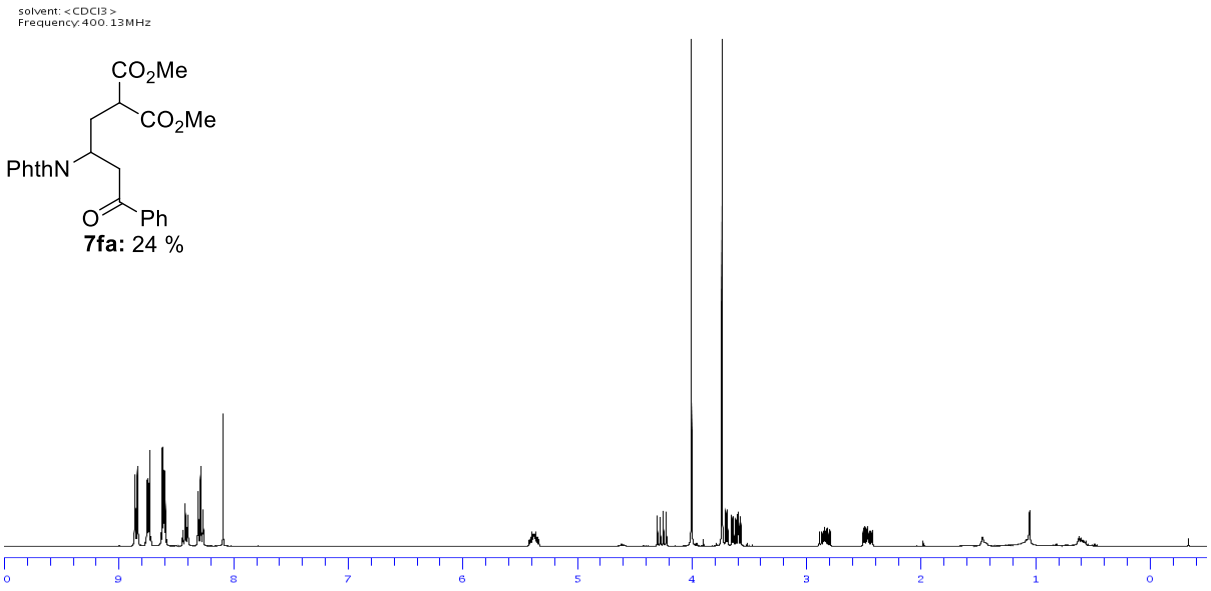
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CO2Me
PhthN
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Ph
7fa: 24 %
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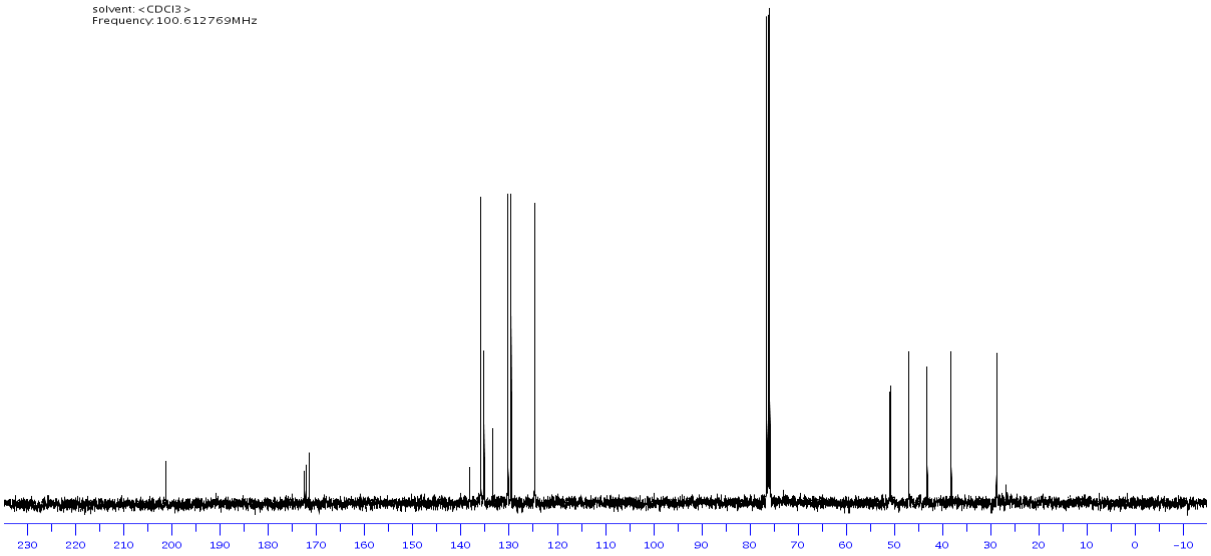
0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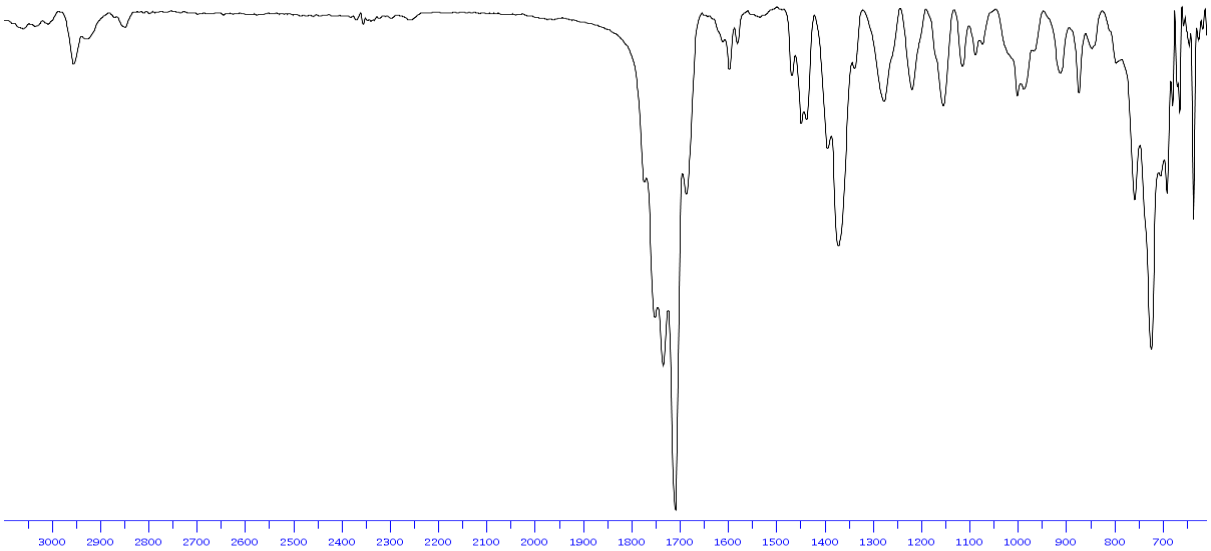
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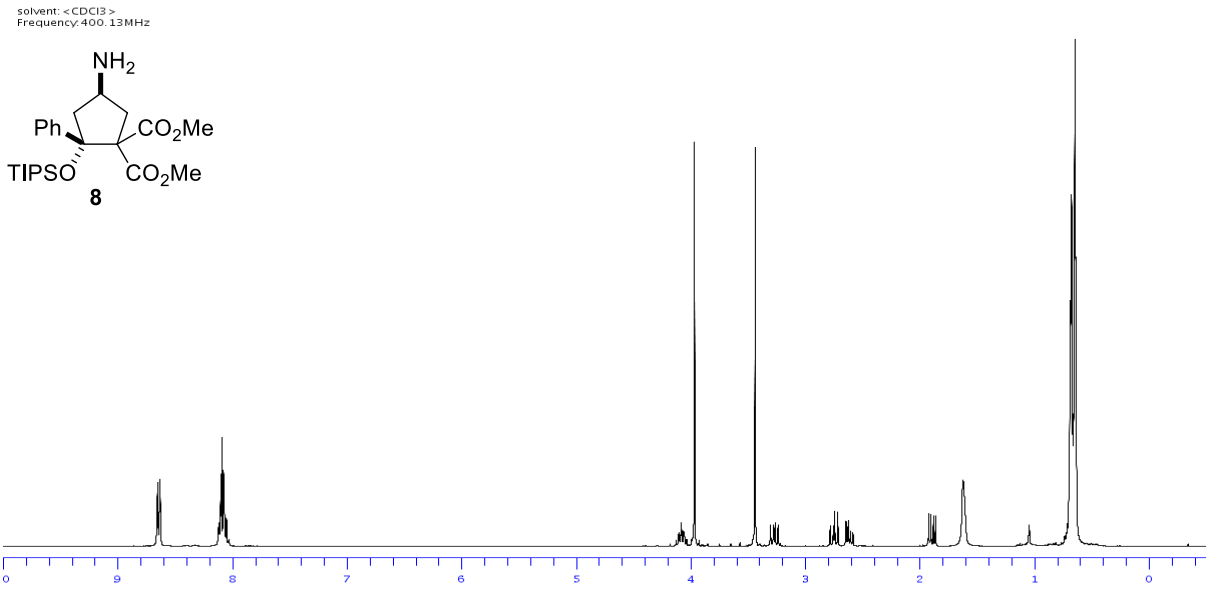
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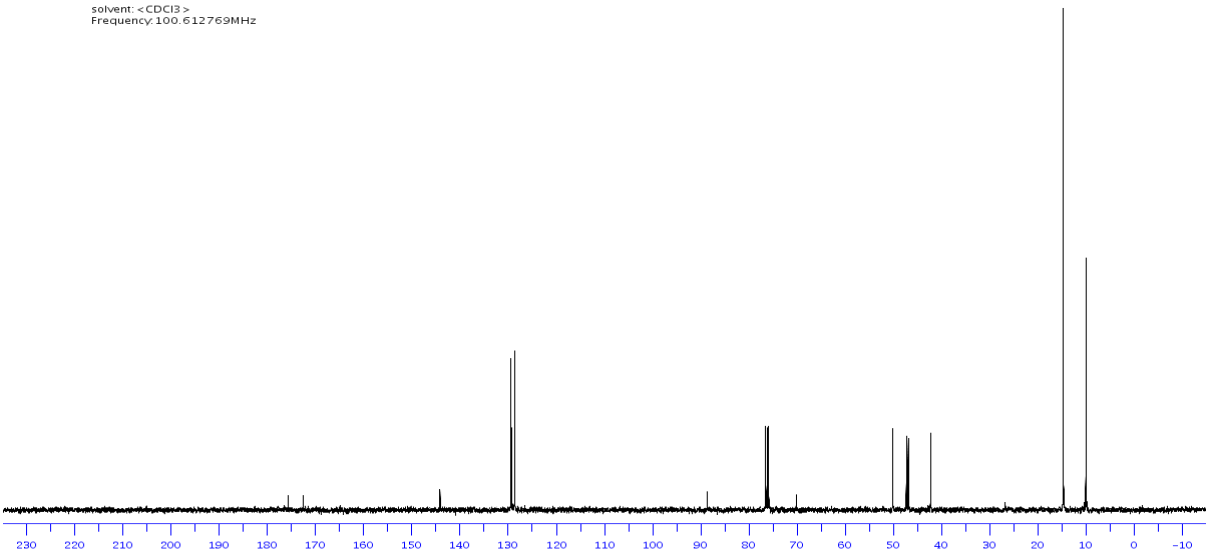
TIPSO
CO2Me
8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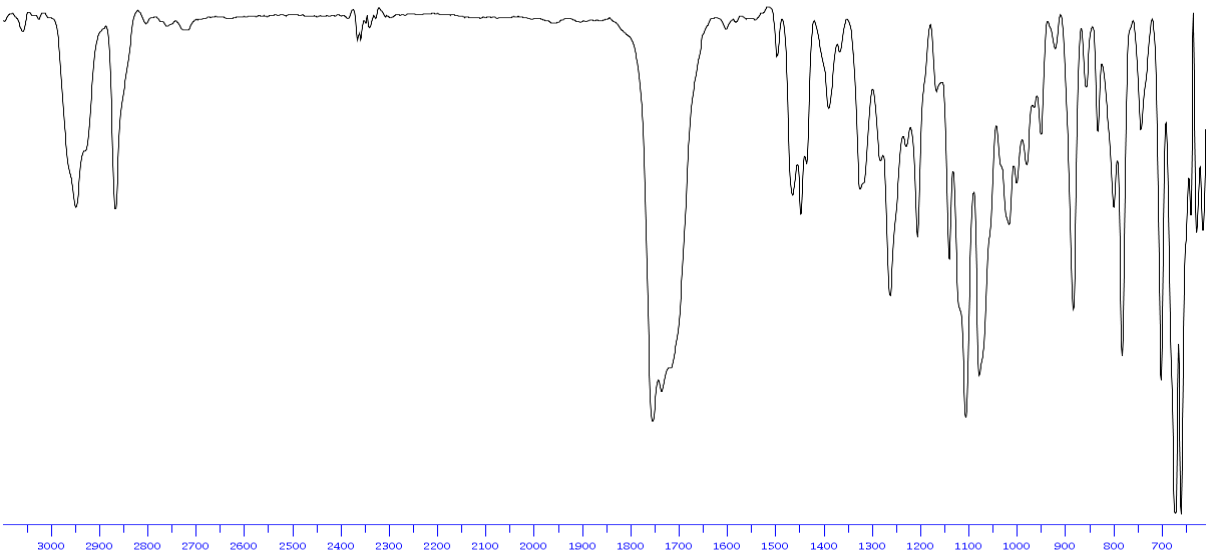
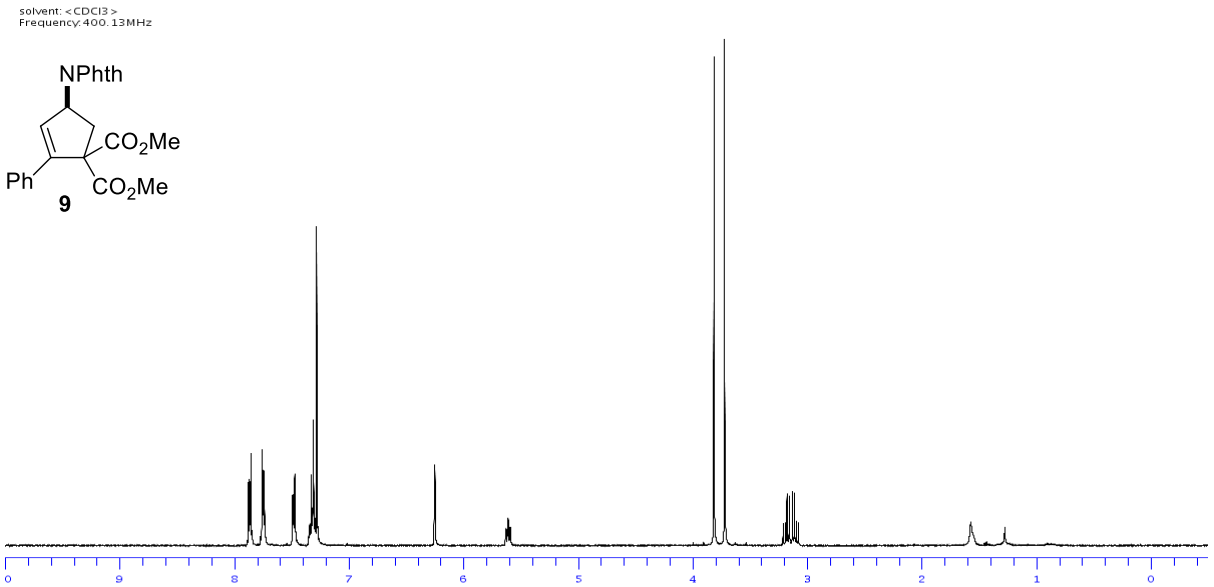
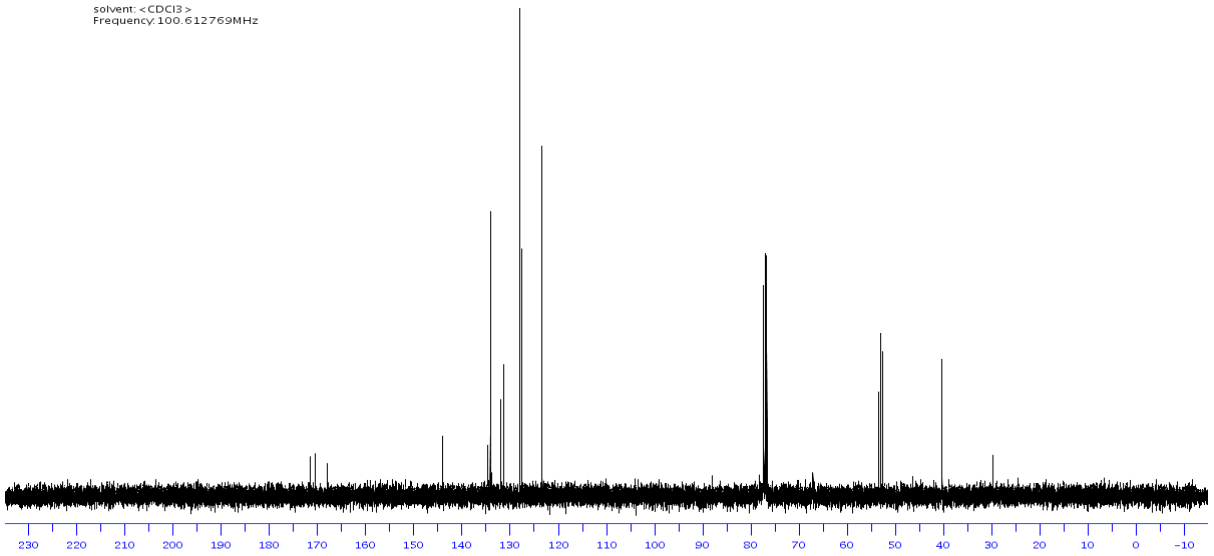
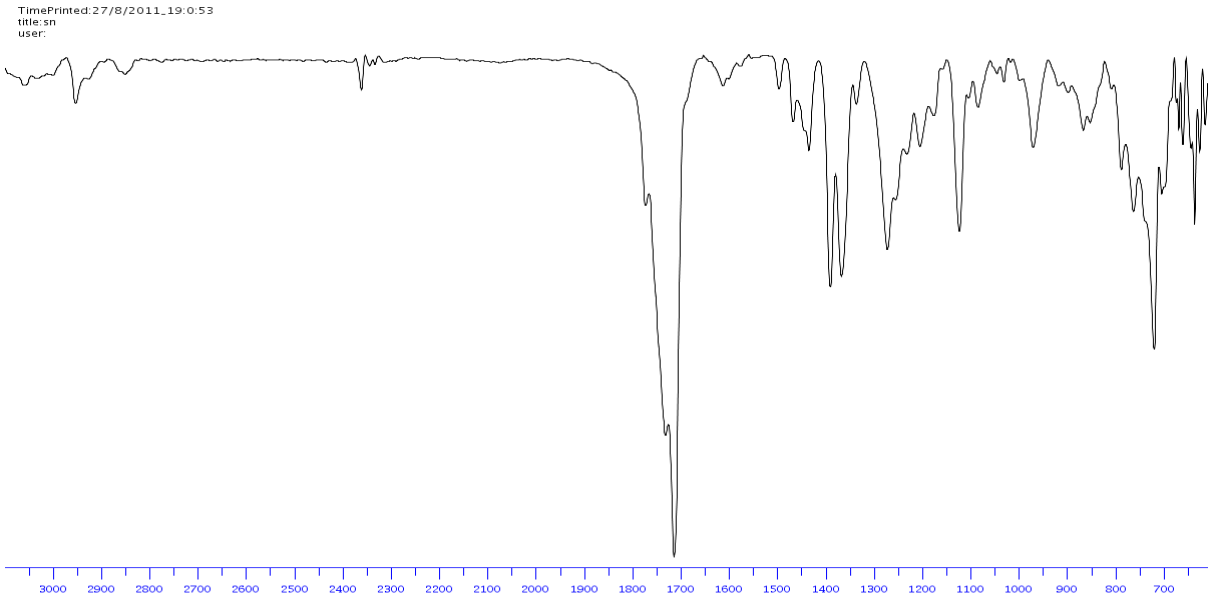



solvent: <CDCl3 >
Frequency: 400.13MHz
NPhth
CO2Me
Ph
CO2Me
9
0
9
8
7
6
5
4
3
2
1
0


solvent: <CDCl3 >
Frequency: 100.612769MHz
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10


TimePrinted:27/8/2011_19:0:53
title:sn
user:
3000
2900
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2700
2600
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1600
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1400
1300
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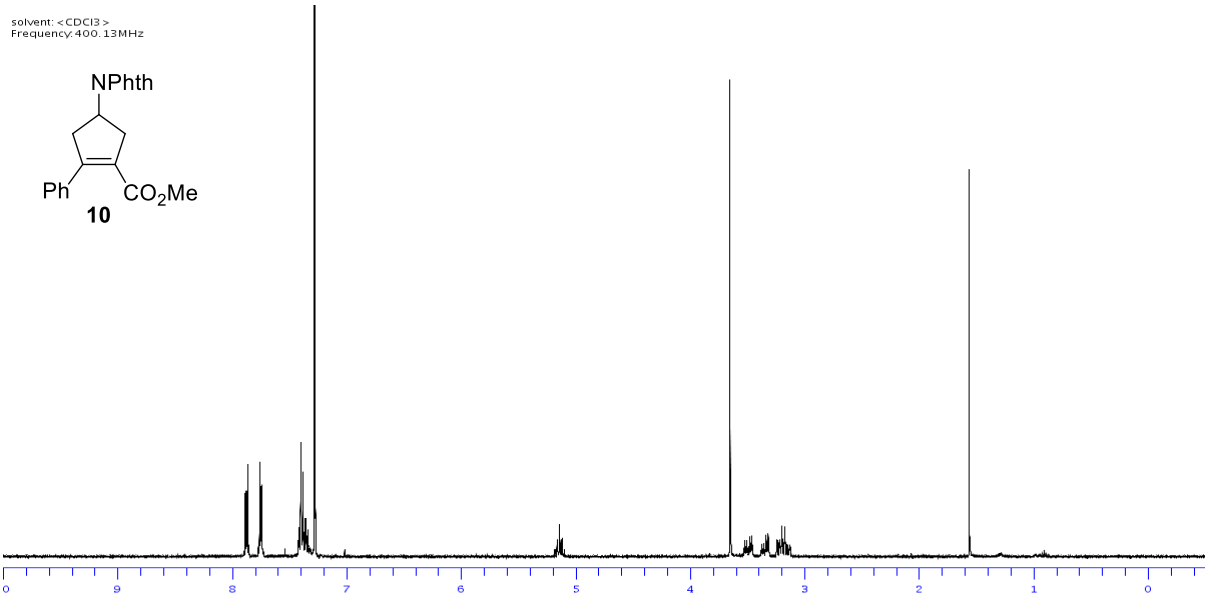
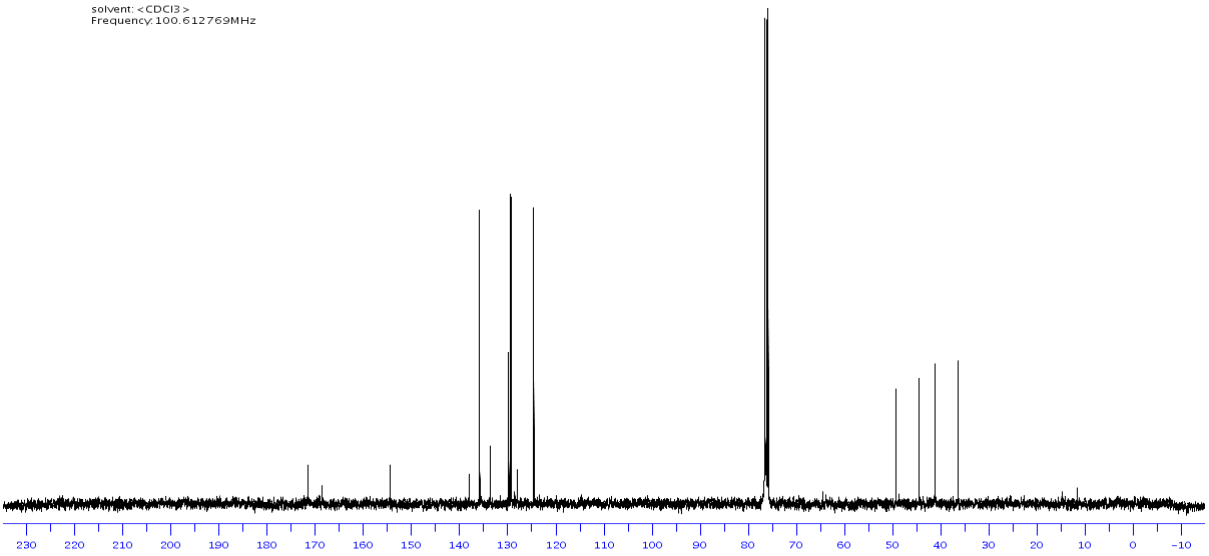
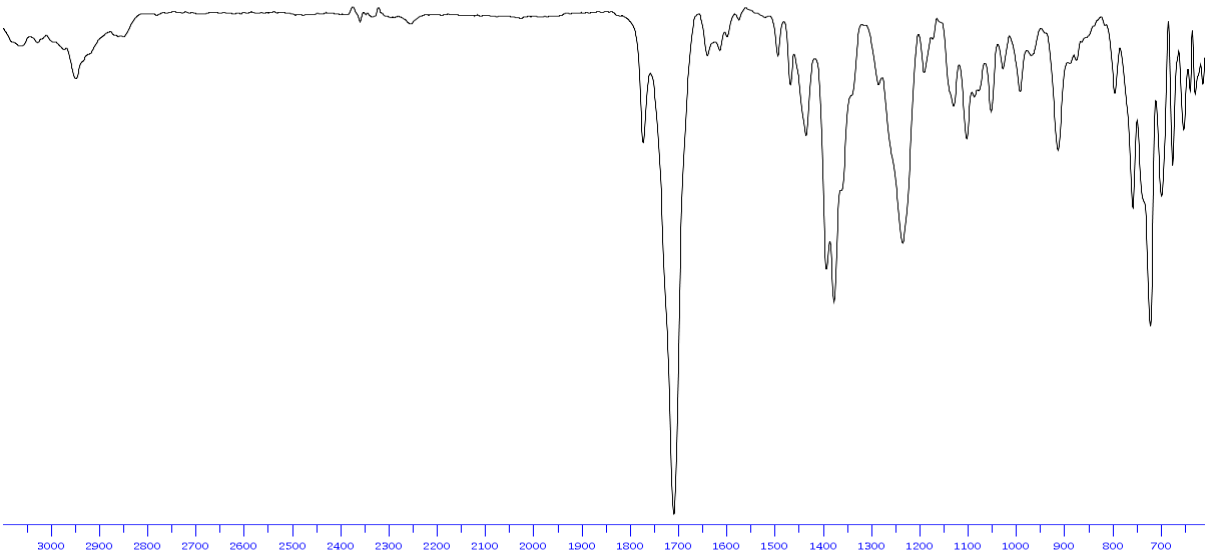
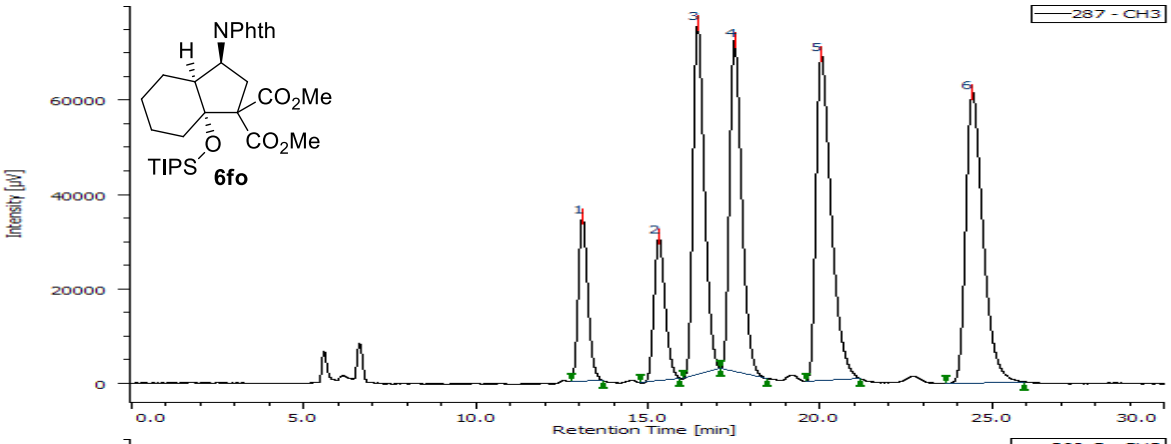
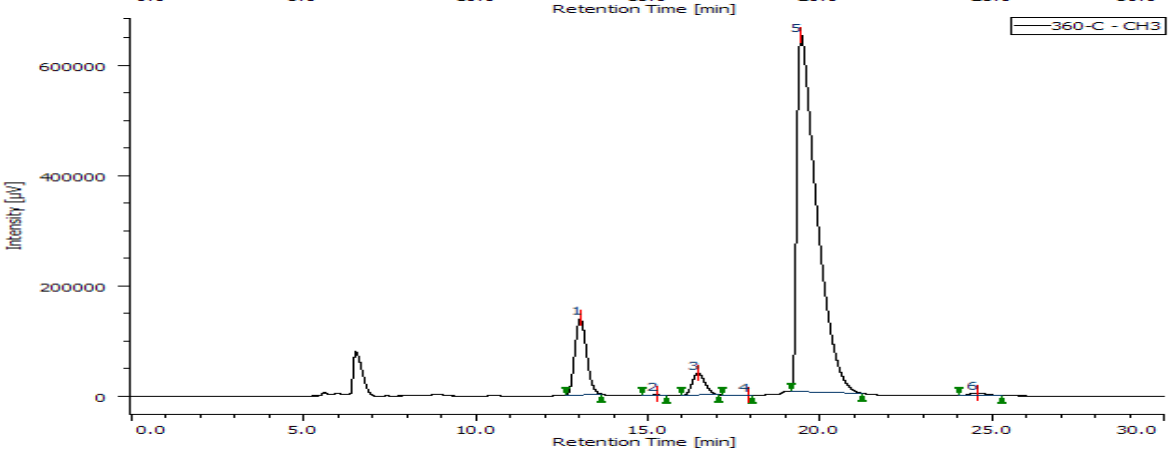
1100
1000
900
800
700

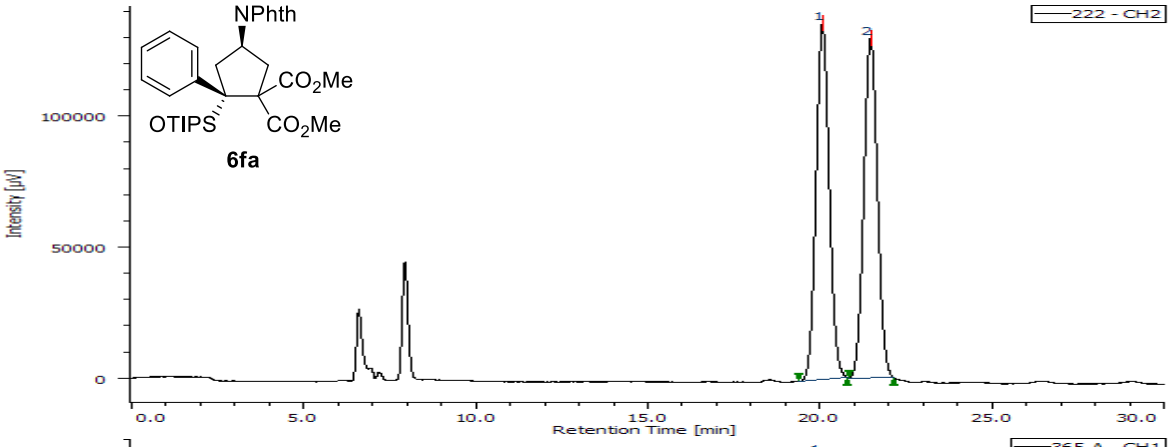

solvent: <CDCl3>
Frequency: 400.13MHz
NPhth
Ph
CO2Me
10

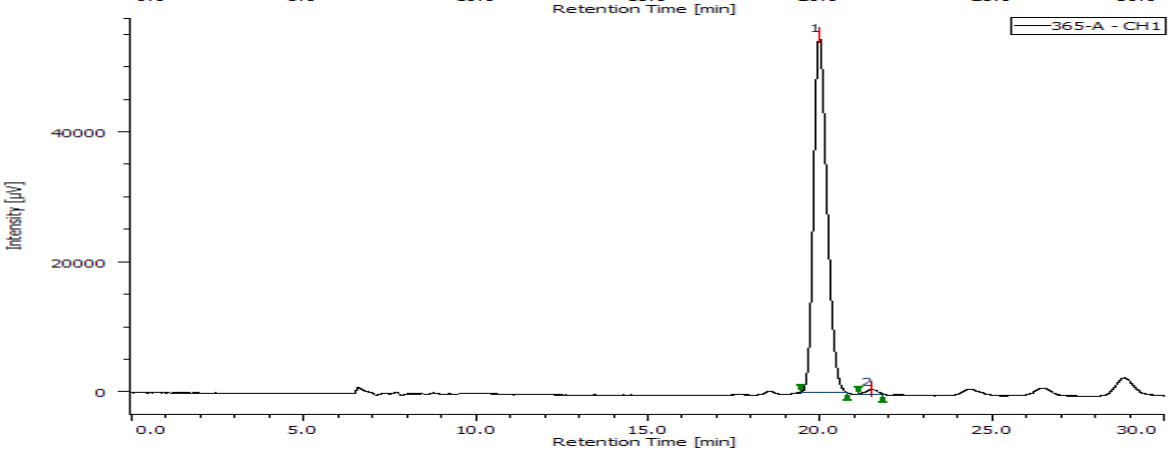

solvent: <CDCl3>
Frequency: 100.612769MHz

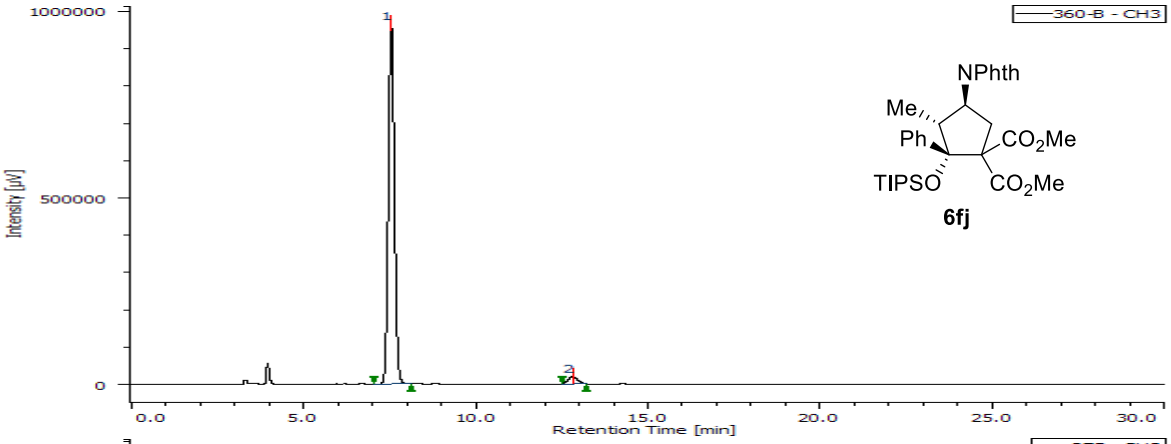


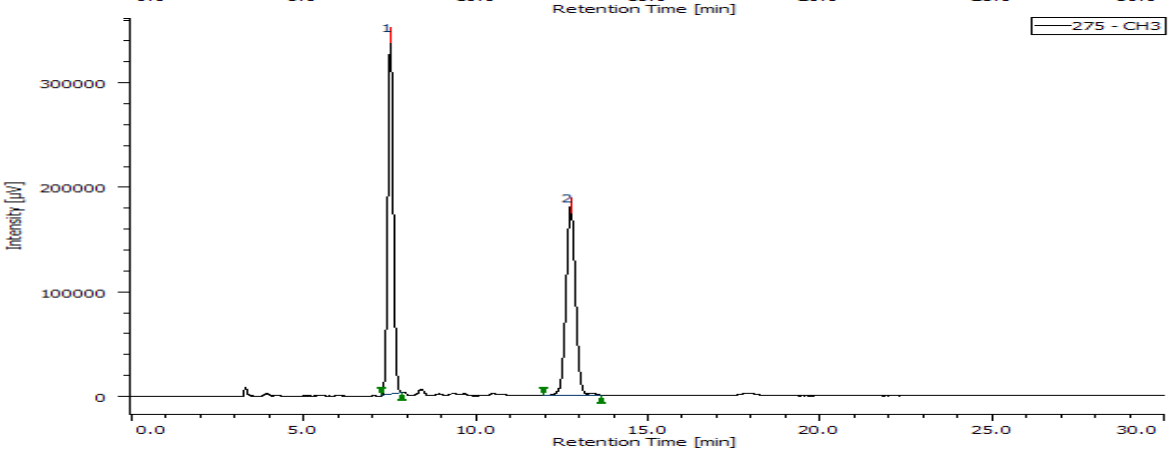

287 - CH3
NPhth
H
CO2Me
CO2Me
O
TIPS
6fo
Intensity [µV]
Retention Time [min]

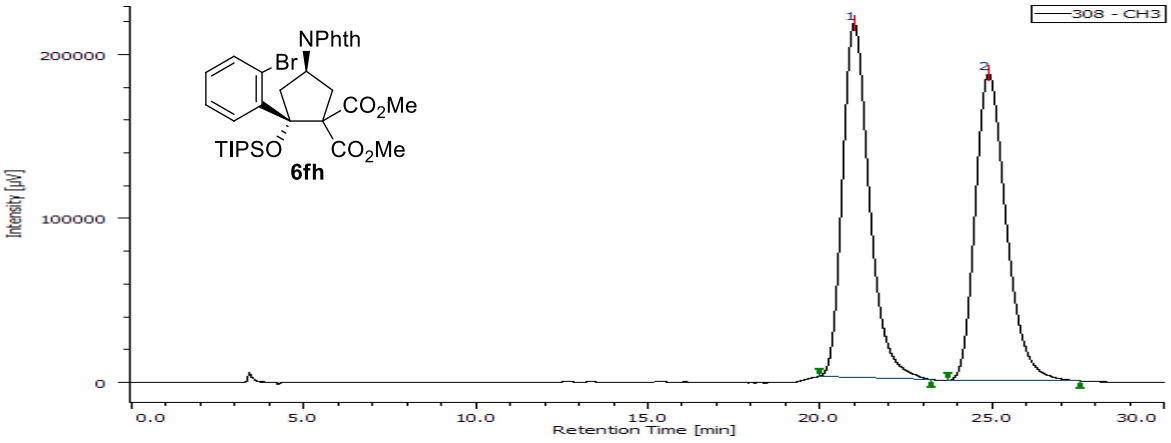

360-C - CH3
Intensity [µV]
Retention Time [min]

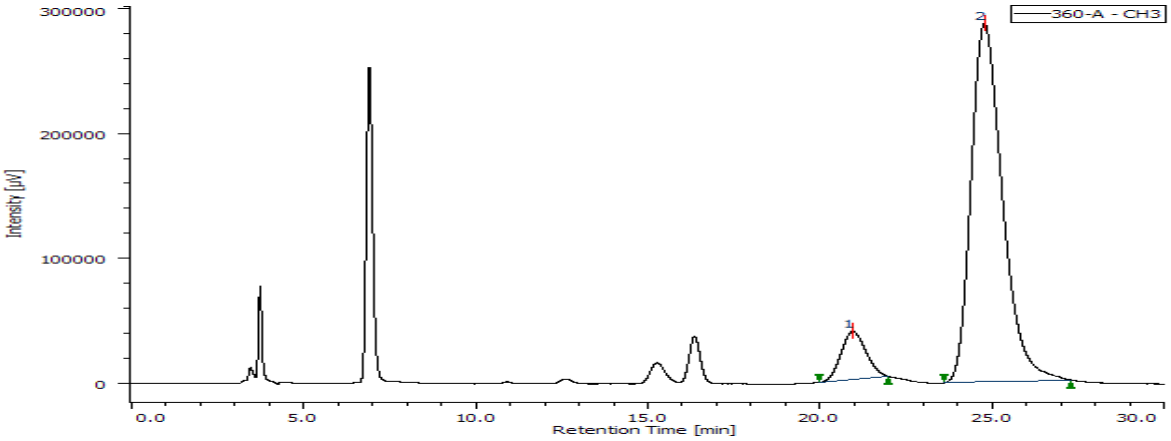

222 - CH2
NPhth
CO2Me
OTIPS
CO2Me
6fa
Intensity [µV]
Retention Time [min]

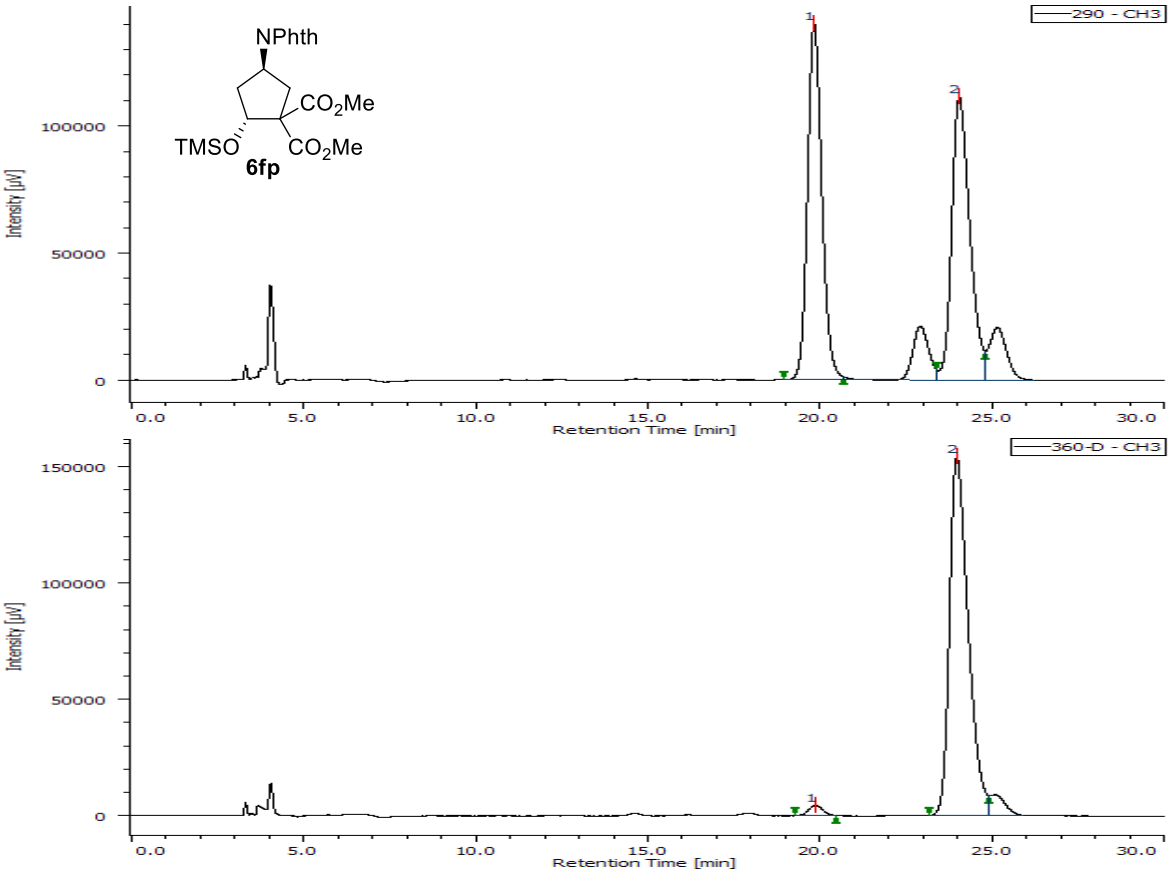

365-A - CH1
Intensity [µV]
Retention Time [min]

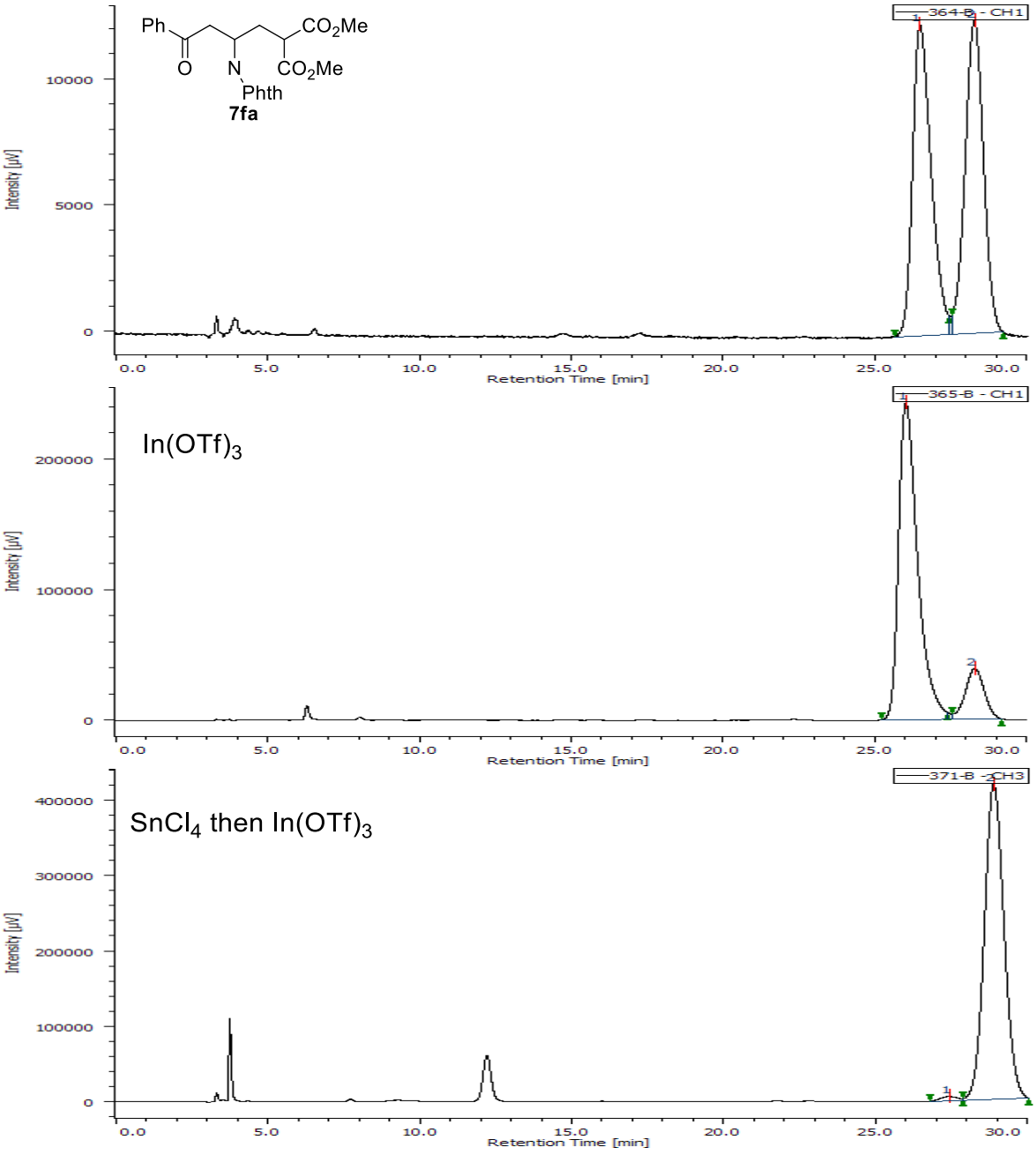

360-B - CH3
NPhth
Me
Ph
CO2Me
TIPSO
CO2Me
6fj
Intensity [µV]
Retention Time [min]

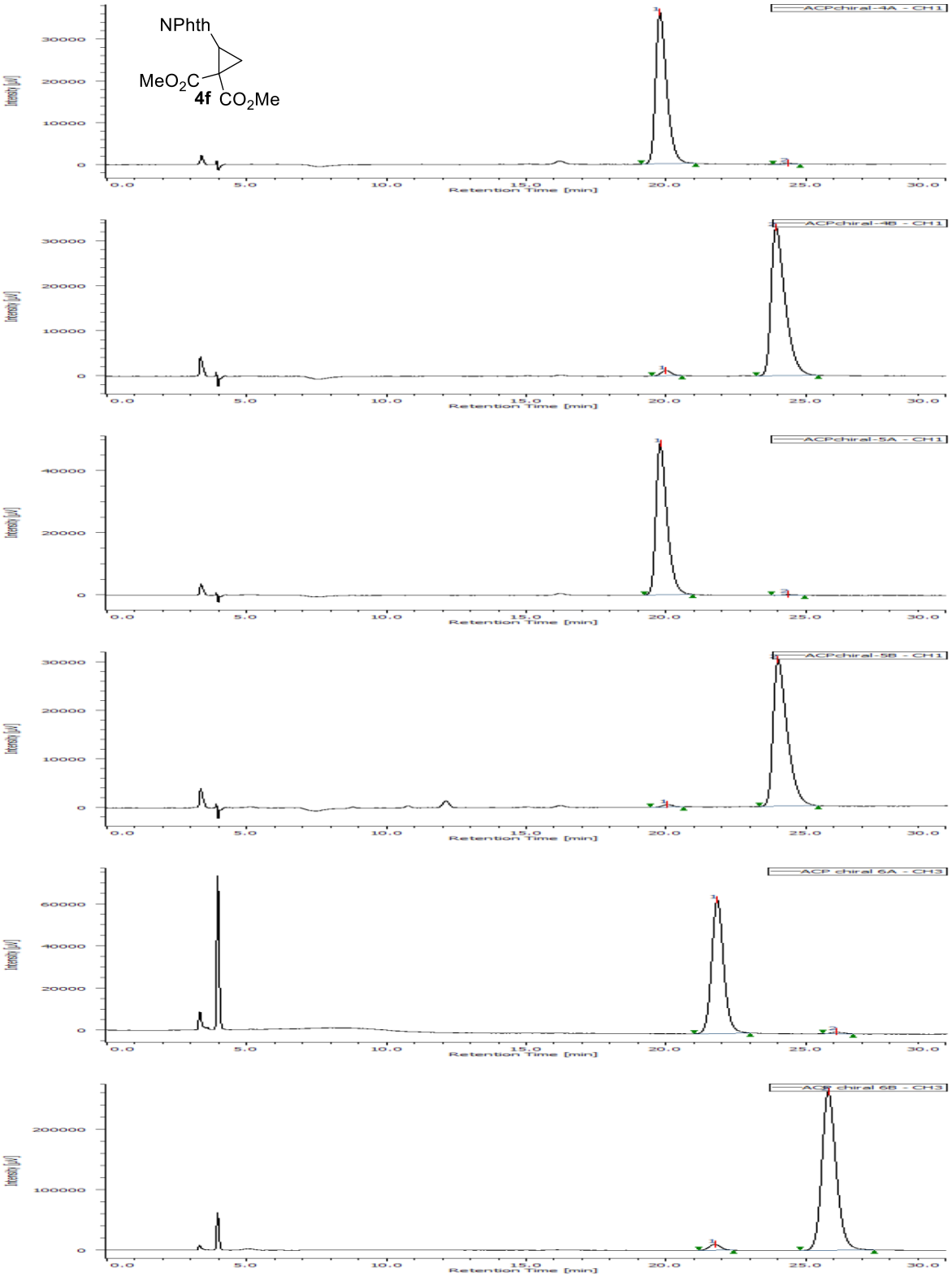

275 - CH3
Intensity [µV]
Retention Time [min]


308 - CH3
NPhth
Br
CO2Me
TIPSO
CO2Me
6fh
Intensity [µV]
Retention Time [min]


360-A - CH3
Intensity [µV]
Retention Time [min]


NPhth
CO2Me
TMSO
CO2Me
6fp
290 - CH3
360-D - CH3
Intensity [µV]
Retention Time [min]
0
50000
100000
150000
0.0
5.0
10.0
15.0
20.0
25.0
30.0


Ph
O
N
Phth
CO2Me
CO2Me
7fa
364-B - CH1
Intensity [μV]
Retention Time [min]
In(OTf)3
365-B - CH1
Intensity [μV]
Retention Time [min]
SnCl4 then In(OTf)3
371-B - CH3
Intensity [μV]
Retention Time [min]


NPhth
MeO2C
4f CO2Me
ACPchiral-4A - CH1
ACPchiral-4B - CH1
ACPchiral-5A - CH1
ACPchiral-5B - CH1
ACP chiral 6A - CH3
ACP chiral 6B - CH3
Retention Time [min]